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NEW YORK, JUNE, 1894.

EDITORIAL NOTES.

IN commenting upon the paper read before the New York Railroad Club in January, by Mr. Joughins, on Iron Cars, *Indian Engineering* says that "it seems a little curious to an Indian engineer to find a question that has been decisively answered long ago for this country, being just opened in America. We may, perhaps, even congratulate ourselves upon not being so very much behind the times after all. Another singular point in detail is the discussion about and reluctance to use rivets. All that can be said is, riveted work stands perfectly well in India, and our wagons in the hands of native shunters certainly get a fair amount of knocking about, which would soon show up any weakness." In another column we publish an illustration of one of the iron cars that is now being manufactured by the Leeds Forge Company, and when we consider the great extent to which iron cars have been used and adopted by the railroads of other countries, it certainly does seem strange that this construction is so uncommon here.

THERE is little likelihood that the Master Car-Builders' Committee on Brake-Shoes will be able to make a report at the coming convention. The work which they have undertaken is so great that time enough has not elapsed since the commencement of the trials to wear out the shoes. We understand that 13 firms are represented in the trials. The standard of comparison is a soft cast-iron shoe made at the foundry of the Pennsylvania Railroad Company at Altoona. The general method of procedure is to equip one truck of a car or tender with the soft cast-iron shoes, and the other with the shoe to be tested, so that the number of brake applications will be the same. When this work is completed there will be a mass of data for some one to sift out and arrange, that will involve not only an immense amount of work, but demand very careful attention on the part of the committee doing it, for the contradictory testimony will be more than confusing, as that of things mechanical has a way of being. It is hardly probable, therefore, that we can learn the results of these investigations before the convention of 1895.

THE COMING CONVENTIONS.

To some of the old codgers who have been attending the railroad conventions for nearly or quite a quarter of a century, their annual recurrence comes with more or less feeling of pleasant anticipation, but shaded with many sad recollections. It is only needful to take the list of members of the Master Mechanics' Association beginning with 1870, to learn how many of them must now be crossed out, and how few remain to answer to their names. Beginning with Isaac Dripper, the first on the list for that year, and following it down, the names of H. M. Britton, N. E. Chapman, S. M. Cummings, J. A. Durgin, Howard Fry, Edwin Garfield, Samuel J. Hayes, C. F. Jauriet, J. W. Philbrick, James Sedgeley, W. S. Hudson, H. L. Leach, W. F. Turriff, and W. Woodcock must all be marked out. Of the active men of that time, James M. Boon, H. A. Little, Morris Sellers, J. H. Setchel, C. A. Thompson, Reuben Wells, and J. N. Lauder are still left. The annual reports from 1868 to 1893—twenty-five in all—form quite a library and bear evidence to the continuity of the work of the Association, even though their contents do not come up to the higher standard, which the technical education and the advances which have been made in mechanical engineering since the early period of its existence would demand. During the quarter of a century of the history of this Association and its sister organization, the Master Car-Builders' Association, they have both passed through many vicissitudes. The complaint is often made that they do not accomplish as much as they should. No human organization ever does. It was said by a distinguished statesman that "experience has always shown, and reason shows, that affairs which depend on many seldom succeed." When the co-operation of a considerable number of persons is required for the accomplishment of any purpose, all kinds of capacities must act for the achievement of a common end. In the direction and control of different sorts of people all degrees of intelligence, ignorance, prejudices, interests, and wrong-headedness must be encountered. Those who earnestly and honestly try to control and influence the action of considerable numbers of people must have, first, the intelligence to know what object should be aimed at, next unflagging persistence, infinite patience and unbounded charity to shape the opinions, adjust the views, tolerate the stupidity, deflect the obstinacy, lead the timidity, and sometimes crush the opposition, which is quite certain to be arrayed against any measure which goes counter to the practice, the habits, or is outside of the knowledge of those whose co-operation is required to carry such measures to a successful issue. The process by which wise political action is evolved out of representative bodies was very well expressed by a French statesman,* who said:

"Every society, according to its interior organization, its antecedents, and the aggregate influences which have or still do modify it, is placed to a certain extent in a position to apprehend truth and justice, and is in a measure disposed to conform itself to this law. . . . This sum of just ideas and loyal wills is dispersed among the individuals who compose society, and is unequally diffused among them, on account of the infinitely varied causes which influence the moral and intellectual development of men. The grand concern of society therefore is, that so far as either abiding infirmity or the ex-

* Guizot's "History of Representative Government."

isting condition of human affairs will allow, this power of reason, justice, and truth, which alone has inherent legitimacy, and alone has the right to demand obedience, may become prevalent to the community. The problem evidently is to collect from all sides the scattered and incomplete fragments of this power that exist in society, to concentrate them, and form them to constitute government. In other words, it is required to discover all the elements of legitimate power that are disseminated throughout society, and to organize them into an actual power—that is to say, to collect into one focus and realize public reason and public morality, and to call them to the occupation of power."

An exactly analogous process must occur in technical associations such as we are writing about, in order to "collect from all sides the scattered and incomplete fragments of the power of reason, justice, and truth, to concentrate them and organize them into an actual power." That is what the Master Mechanics', Master Car-Builders' and other similar associations have been aiming to do, with more or less unanimity of purpose, during the whole of their existence.

There have been and are still some influences which are more or less antagonistic to such purposes. A very considerable portion of those who attend the meetings go for amusement and pleasure alone, or chiefly, and a good many who are there each year have other aims and objects. The entertainment question is one which has come up annually, and been the cause of a good deal of irritation to some of those who are most interested in what should be the true purposes of the Association. As long ago as 1875 the Master Car-Builders' Association adopted the following preamble and resolution:

Whereas, The practice of entertaining the members of this Association by its friends has become an established custom, and has thus assumed somewhat the character of an obligation, to which those who have so generously dispensed hospitality have in a measure felt themselves obliged to conform; and

Whereas, The expenditure of time and money for this purpose has in many cases been very much greater than the members of this Association have a right to expect should be devoted to their enjoyment; and

Whereas, The expense of such hospitality has in some cases been interpreted as having a significance which has been the cause of embarrassment to members;

Therefore, We desire by this resolution, first, to express our thanks for the liberality of our friends in the past; and, secondly, to make the request in this public way that in the future there shall be no more expenditure of money for the public entertainment of members of this Association.

The record says, "the preamble and resolution were *unanimously* adopted." Some years thereafter a member of the Association was entrusted with the duty of collecting together the "Standard Dimensions, Forms of Construction, etc., adopted by the Master Car-Builders' Association," which were thereafter printed each year at the end of the annual reports, and also in a separate pamphlet for the convenience of the members. The person entrusted with the duty of making this compilation appended the above preamble and resolution to the other "standards." This, it is true, was done without any authority for so doing, but for years it appeared in the annual reports in the position described, but whether it was a "standard dimension" or a "form of construction" was never decided. A few years ago the list of standards was revised, and the committee charged with that duty discovered the pious fraud and omitted the resolution; but it has never been repealed. It stands to-day as the deliberate action of the Association, although apparently it has had little if any effect. It may be said, though, that there is considerable feeling against the practices which the quoted resolutions were aimed at. Like the liquor traffic, though, these practices are difficult to control. Prohibition don't prohibit. High license, too, has little effect. What influence the hard times will have this year remains to be seen. Contributions for the entertainment of the members of the Association, their wives, their sisters, their cousins and their aunts, will probably be less liberal than in former years. Some of the members who are most deeply interested in the welfare and usefulness of the organizations referred to are earnestly looking for some means of controlling the exuberance of their friends' hospitalities. The Norwegian system is suggested. In that country it was found, as it has been everywhere else, that the traffic in alcohol could not be controlled so long as it was in the hands of irresponsible dealers. The State, therefore, has created organizations in that country over which they keep complete control, which are authorized to sell liquor under certain regulations, which the government is thus able to enforce. Let our railroad friends adopt an analogous plan—that is, appoint a committee charged with the duty of co-operating with the Entertainment Committees, and of restraining the expenditures of money at the conventions. Such a committee could thus exercise a reasonable restraint over some of the ambitious young men who become unduly elated when entrusted with the duty of hospitality. A great deal of absurd extravagance has often been indulged in which it would be for the good of the Associations if it were restrained.

Another question that is likely to come up again this year is some arrangement by which less time would be consumed by the two conventions. Few who occupy the dual positions of Locomotive and Car Superintendents can afford to devote two weeks to those meetings. To the consolidation of the two there has always been great opposition. It is not apparent either that any great gain would result therefrom. It makes very little difference whether the same or two sets of officers preside over the meetings devoted to locomotives and those devoted to cars. As the gain of consolidation is not apparent, the obvious course is not to do it; but that will not prevent both meetings being held during the same week. Let the Master Mechanics hold their first meeting on Monday evening, which will enable them to finish up the preliminary routine business, and have the decks cleared for action next morning. Then devote Tuesday and Wednesday to the locomotive department, and let the first meeting of the Car-Builders be held on Wednesday evening, which will give them the whole of Thursday and Friday. If important business should remain for the Master Mechanics on Wednesday afternoon, it would be possible to continue their meetings on Thursday, and the two Associations could lap over each other. The Car-Builders could continue theirs on Saturday, if need be, or even extend them over to the following week in cases of emergency. With a little supervision of the Executive Committees to economize time, and of a Norwegian Committee to limit entertainments, it would be possible to accomplish as much in one week as is now done in the two, with perhaps fewer head and heart aches at the end of that time.

GRAPHITE AS A LUBRICANT.

To the Editor of THE AMERICAN ENGINEER:

Your review editor quotes the following paragraph from our pamphlet on "Graphite as a Lubricant":

"The difference between a perfectly pure graphite and one almost pure, but still totally unfit for lubricating, cannot be detected by either sight or touch; the buyer's only guarantee of the purity is the name and reputation of a responsible manufacturer." And adds:

"Now what we would like to know, and probably some of the readers of this pamphlet will be disposed to join us in our 'quest,' is how do the manufacturers know whether the graphite 'is perfectly pure'? If you can't see nor feel whether it is pure, how can it be known that it is pure? In other words, the buyers and users of graphite would like to know how it can be tested to know whether it is pure or not."

This furnishes us with an opportunity that we are not slow to take advantage of. Your review editor evidently thinks that "seeing is believing, and feeling is the naked truth."

This old saw is not, however, of any use in testing graphite, though it may have its application elsewhere. The only way to "know" whether graphite is perfectly pure is to test it in a laboratory with the aid of chemistry. Therefore, unless he can make a laboratory test, "the buyer's only guarantee of the purity is the name and reputation of a responsible manufacturer." The Dixon Company, knowing the ore used, is reasonably sure of the purity of its product, but we do not stop there, we select samples at the different stages of manufacture and send them to the laboratory for test. Our purifying processes are continued until the required degree of purity is obtained. In case a test shows that the stock is not as rich as usual, that particular batch is turned into another channel and does not become "Dixon's Perfected Flake Graphite." The reason why "you can't see nor feel whether it is pure" is because the impurities are coated with the graphite, and become so smooth and black as to bid defiance to the sense of feeling and seeing. It is only when introduced into engine cylinders and bearings of machinery that particles of quartz and other impurities manifest themselves and begin their work of destruction. Pure flake graphite is now indispensable in every well-equipped engine-room or machine shop. Its uses are manifold, but common plumbago and black lead, which are so often offered for sale as lubricants, are worse than worthless. Perfected flake graphite has had an up-hill fight in overcoming prejudices that have been the outcome of experiments made with impure graphite and cheap plumbago.

JOSEPH DIXON CRUCIBLE COMPANY.

[The Dixon Crucible Company have not, we think, given a quite satisfactory answer to our inquiries. They say "the only way to 'know' whether graphite is perfectly pure is to test it in a laboratory with the aid of chemistry," and that they "select samples at the different stages of manufacture and send them to the laboratory for test." Now among our readers are a considerable number of people who have more or less knowledge of chemistry. What such people doubtless would like to know is the processes which are employed in the laboratory. Our correspondent's reply recalls the old story of the man who had but one leg. A woman expressed a great deal of curiosity to know how he lost the other one. He said he would tell her if she would agree not to ask any more questions. She agreed to this, and was told "it was bit off." Some of our readers will doubtless have the same kind of consuming desire to know how the Graphite Company test their products, after they "send it to the laboratory," that the woman had to know what it was that "bit off" the man's leg.—EDITOR AMERICAN ENGINEER.]

NEW PUBLICATIONS.

BEESON'S INLAND MARINE DIRECTORY. By Harvey C. Beeson, Chicago, Ill. 290 pp., 9½ × 6½ in.

This is the seventh annual edition of this Directory, and, like all other annuals, it has a tendency to grow with each issue. The contents of the book are, first, 32 pages of advertisements which will make rival publishers envious. These are followed by a portrait of the author or compiler and a list of American Steam-vessels of the Northwestern Lakes. In this and in other lists which follow the class, name of vessel, tonnage, date and place of building, name and residence of owner or manager, are all given. There are other similar lists of American sailing-vessels, vessels whose names have been changed, small steam-vessels of the Northwestern lakes, Canadian steam-vessels and Canadian sailing-vessels of the Northwestern lakes. These tables are followed by a number of others containing data and statistics relating to marine matters on the great lakes, instructions to masters of vessels, pilot rules, extracts from revised statutes, and ends with a classified directory of all the more important lines of trade connected with the marine interests on the Northwestern lakes. Many engravings of external and internal views of lake ships are scattered through the volume, which is of very great interest and value to all who are concerned in the immense traffic which is now carried on on these great internal highways of the continent.

HOW TO RUN ENGINES AND BOILERS. *Practical Instruction for Young Engineers and Steam Users* By Egbert Pomeroy Watson. Second Edition. Spon & Chamberlain, New York. 125 pp., 6½ × 4¼ in., $1.

Mr. Watson is the well-known editor of *The Engineer*, which is published in New York, and is the author of a number of books of the "practical" type intended for men in charge of engines and other machinery. What he writes is always readable and often instructive, and has the merit that wayfaring and wise men can understand what he writes. Whether the other kind of people mentioned in the Scriptures comprehend his books we have never been able to find out.

The first four chapters of the book before us are on the management of boilers. These are followed by others in which the care of the piston, valves, valve-gear, governors, connecting-rods, cranks and crank-pins, journal-bearings, setting valves and eccentrics, making joints, care of condensing engines, pumps, etc., are all discussed, and many shrewd suggestions are given. The last chapter he calls "a little sermon," and is on the Highest Qualities Demanded—a suggestive title; and a good deal more might have been written under that heading with advantage and profit to his readers. He might, for example, have added, "Fear God and keep His commandments, for this is the whole duty of man," which would have been comprehensive.

TRADE CATALOGUES.

NEW ILLUSTRATED PRICE-LIST OF PATENT ELECTRIC VISES, JACK SCREWS, ETC. The Capital Machine Tool Company, Auburn, N. Y. 8 pp., 4½ × 7½ in. This little book is what its title indicates, but why the vises described in it are called "electric" does not appear. A little description of their points of superiority would, it is thought, be advantageous to both publisher and reader.

CATALOGUE AND PRICE-LIST OF MODERN MEASURING INSTRUMENTS FOR ALL TRADES AND SCIENTIFIC PURPOSES. E. G. Smith, Columbia, Pa. 16 pp., 3½ × 6½ in. The principal instruments which are described in this little publication are caliper squares or graduated beam-calipers, vernier calipers, and screw micrometers, the manufacture of which is a specialty with the publisher.

THE RUE MANUFACTURING COMPANY. Philadelphia. Manufacturers of the "Little Giant," "Fixed Nozzle," and "Unique Injectors," Rue's Patent Boiler Washing and Testing Apparatus, etc. 16 pp., 5¼ × 9 in. The title describes the contents of this publication very fully. The different kinds of injectors are illustrated and their uses explained, and sizes, capacity, etc., given, and methods of attachment shown.

AMERICAN TUBE WORKS. Boston, Mass.: Seamless Drain Brass Pipe for Plumbing. 32 pp., 3¾ × 5¾ in. The purpose of this little book is to commend the use of brass pipe generally, and that made by the American Tube Company in particular, for plumbing work. It gives a series of testimonials and a large list of buildings in which this kind of pipe has been used, and which one of the testifiers says, when "properly fitted is an everlasting job."

CONCRETE OR MONOLITHIC CONSTRUCTION. Ernest L. Ransome's Series of Inventions in the Manufacture and Use of Concrete. Ransome & Smith Company, 269 Dearborn Street, Chicago. 87 pp., 3¾ × 6½ in. The principal invention described in this publication is Ransome's Concrete and Twisted Iron Construction. This consists in the use of square or rectangular iron bars, which are cold twisted so as to form a continuous bend with the concrete in which they are permanently imbedded. Very full information is given of the methods of employing this kind of construction for building purposes, monolithic subways, sewers, well molds, vault lights, etc.

REPORTS OF TWENTY-FOUR TRIALS OF THE HAZELTON OR PORCUPINE BOILER, *Arranged to Show the Performance of this Boiler under Varying Conditions of Service and with Different Grades of Fuel.* The Hazelton Boiler Company, 716 East Thirteenth Street, New York. 32 pp., 3½ × 6½ in. The "porcupine" boiler resembles the same type as the one illustrated on p. 228 of the last number of THE AMERICAN ENGINEER. The little pamphlet before us contains the reports of 24 tests of the "porcupine" boilers made at different places and with different kinds of coal. These tests show the remarkably high average evaporation of 8.92 lbs. of water evaporated, at temperature of feed per pound of coal. The highest rate is 10.82 lbs. with bituminous coal, and the lowest 8.05 lbs. with buckwheat. Attacking a porcupine is proverbially unpleasant, so we will it to others to dispute the results of these tests, if they are disposed to do so.

AUTO-PNEUMATIC RAILWAY SIGNAL COMPANY'S DESCRIPTIVE CATALOGUE OF THEIR LOW-PRESSURE PNEUMATIC INTERLOCKING SIGNALS. Rochester, N. Y. 36 pp., 5¼ × 9 in. This is a well-written, well-printed, and clear description of the apparatus made by this Company for operating switches and signals by low-pressure air. It is illustrated with a number of wood-cuts and outline engravings which show the construction of the apparatus clearly. The title-page bears the name of H. B. La Rue as General Manager of the Company, who thus announces that he is ready to receive orders in his new position, in which his friends and acquaintances will wish him abundant success.

THE IRON CAR COMPANY. 115 Broadway, New York. 9 × 3¾ in., 24 pp. This elongated publication is a prospectus of a Company, the purpose of which apparently is to build cars for the transportation of fruits and other perishable products from the Southern States. The principal burden of the text is that the capital stock of the Company is $3,000,000, and that the present price of shares is $15 for one full-paid share of the par value of $100. The "enterprise," it is said, "is based on the mutuality of the interests of the people of one country, but separated by zones wide enough to create months of difference in climatic development." It would seem as though stock with such a "base" ought to be worth at least $15 for one full-paid share.

SOUVENIR CATALOGUE, WORLD'S COLUMBIAN EXPOSITION. W. & L. E. Gurley, Troy, N. Y. 64 pp., 7 × 10 in.

In "a sketch of their business and an announcement of their book," the Messrs. Gurley say that "so many of our customers are never seen by us, and never had an opportunity to visit our factory, that it occurred to us to take occasion of the World's Columbian Exposition to present this book, giving an idea of the various kinds of field instruments that we make, and some views of the place where they are made."

It opens with portraits of the two founders of the business, William and Lewis E. Gurley. The former died in 1887, the latter still takes an active part in the business.

Very good views of the outside and inside of the building occupied by the firm are given. These include views of all their principal workshops, their sales-room, and exhibit at the Chicago Exhibition. About 50 wood-engravings with brief descriptions are there given, which illustrate the principal instruments made by the firm. These include Transits of various kinds, Gradienters, Levels, Plane Tables, Compasses of various kinds, Odometers, and Current Meters. This firm have been pioneers in this business, and the book before us bears testimony to their well-earned success.

THE CONNERSVILLE BLOWER COMPANY, CONNERSVILLE, IND., *Manufacturers of Positive Pressure Blowers, for every Purpose requiring Air or Gas to be Delivered under Pressure.* 16 pp., 5¼ × 9 in. In this pamphlet the "Cycloidal Blower," manufactured by this Company, is very fully described. It consists of two revolvers or impellers, whose sectional form resembles a figure 8, and their length is about twice their major diameter. These impellers occupy the relation to each other which a vertical figure 8 would to one placed horizontally thus $\frac{8}{\infty}$, and each is carried on horizontal shafts, and the two are enclosed in a case and are driven by gear wheels outside the case. The outside contour of these impellers is composed of epi and hypo-cycloidal curves, and on the exact form of these curves much of the efficiency of the blower depends. In their catalogue the Company describe the method of shaping these impellers, their form and construction, and also a very ingenious journal-box intended to take up wear on the journals. The publication concludes with descriptions and illustrations of different classes of these blowers driven by engines and electric motors. With the exception of the first engraving in the book, they are all excellent, and are good, old-fashioned wood-cuts, than which no other kind of art can represent a machine so satisfactorily.

EARTHENWARE HOUSES. Charles Carroll Gilman, Eldora, Ia. 24 pp., 6¾ × 9½ in. The contents of this pamphlet apparently are intended to describe some of the author's inventions to be used in the construction of houses, but it is not easy for a busy man to understand just what these inventions are from the pamphlet before us. Apparently it is for another process of making wood "incombustive," and for the manufacture of "fibrous brickwares." The latter is described as follows: "The formulæ for its manufacture differs so far from the others as to employ black soils largely with clays, too fat for brick-making, and commingling asbestos in greater or less quantities with the vegetable matter that enters the plastic composition, which, indestructible by the subsequent firing processes, remains in the burned wares as a fiber to bind them as jute does 'staff;' for great porosity is only had by excessive adulteration of the clays with combustible matter." This is not lucid. For the benefit of the author of this, and those who write other similar productions—and their readers—the remarks of Herbert Spencer will again be quoted: "A reader or listener," he says, "has at each moment but a limited amount of mental power available. To recognize and interpret the symbols presented to him requires part of this power; to arrange and combine the images suggested by them requires a further part; and only that part which remains can be used for framing the thought expressed. Hence, the more time and attention it takes to receive and understand each sentence, the less time and attention can be given to the contained idea; and the less vividly will that idea be conceived." Mr. Gilman's "symbols" have absorbed all the mental power we have been able to give to his publication.

THE DAYTON RAILWAY CROSSING-GATE. Manufactured by the Craig-Reynolds Foundry Company, Dayton, O. 19 pp., 6 × 8¾ in. In the pages of this book the points of superiority of the crossing-gates made by this Company are fully set forth. Two very good illustrations—half-tone engravings—show one set of them open and another closed. Two pages engraved from assembled scraps, cut from newspapers, which give accounts of crossing accidents, are intended to accentuate the necessity of having gates at such crossings. A poetic effusion—we were about to write eruption—occupies the last page. The closing stanza ends thusly:

"Oh, you may toy with buzz-saws coy,
Whenever they're in motion,
Or on a feather in stormy weather
Attempt to sail the ocean;
And even jaw your mother-in-law,
Who always does the bossing,
But don't go near—if death you fear—
The fatal railway crossing."

The pamphlet is admirably printed on coated paper, and there is every reason for thinking that the gates which this Company makes are as good or better than the best; but, really, can it be good business policy for them to publish such poetry? It would seem to incline every railroad manager to leave all his crossings unguarded, in order that he might have the satisfaction of killing as many poets of that kind as possible.

SOUTHERN FACTS FOR HOME-SEEKERS AND TRAVELERS. Mobile & Ohio Railroad. 48 pp., 4 × 7¾ in. Accompanying this "folder" a neatly printed circular was received, in which it is said that it—the folder—"contains complete time tables and other detailed information regarding the road, its officers and agents, and gives the population and altitude of all of the stations; it contains, in addition, a great fund of information regarding the South in general, and our section in particular, condensed into a small compass"—all of which we will confirm.

It is illustrated by some fairly good engravings made from photographs, one of which "shows strawberries, lettuce, onions, celery, cabbage, and turnips, all gathered on the day the photograph was taken. Had the photographer wished," it is said, "he might have also shown in the photograph from the same garden, parsnips, beets, leeks, shallots, radishes, salsify, carrots, and parsley."

Another engraving shows the Healing Springs in Alabama, which are said to be a positive cure for a number of ills, to some of which nearly all full-grown people are subject. It is also said that there are 11 springs, all different. There are enticing engravings of turnips weighing 12 lbs. each, a view of Hon. E. M. Hudson's grape vineyard at Beaver Meadow, Ala., an apple-tree in Tennessee bending under a load of 30 bushels of apples, and a wagon load of Northern land-seekers looking at lands on this road. We confess that we like the looks of the Southern turnips, cabbages, strawberries and grapes better than those of the Northern land-seekers. Probably most readers of this "folder" would rather have the vegetables which are depicted for neighbors than the land-seekers. Pleasantry aside, this publication is full of interesting information of the country through which the Mobile & Ohio Road runs, and on reading it one is strongly tempted to abandon such drudgery as editing a technical paper implies, go South and buy one of those farm tracts of 80 acres, which this "folder" tells us "can be obtained within 2 miles or less

of the railroad, that will produce early fruits and vegetables, most of the cereals, grasses, etc., and where good health and water are guaranteed, for $200."

Those interested in the South, or contemplating emigration, are recommended to write to Mr. E. E. Posey, General Passenger Agent of the Mobile & Ohio Railroad at Mobile, Ala., who will send them a copy of this interesting publication.

BOOKS RECEIVED.

Primer of Navigation. By A. T. Flagg, M.A. 104 pp., 4 × 6 in. London and New York: Macmillan & Co. 104 pp., 4 × 6 in., 35 cents.

Transactions of the American Institute of Electrical Engineers. Vol. X. 719 pp., 5¼ × 8¼ in. Published by the Institute, 12 West Thirty-first Street, New York.

The Magneto Hand Telephone. Its Construction, Fitting up and Adaptability to Every-day Use. By Norman Hughes. New York: Spon & Chamberlain. 80 pp., 4½ × 6 in., $1.

THE MANUFACTURE OF ALUMINIUM.

"At a recent meeting of the Manchester Association of Engineers, Mr. W. S. Sample, of the Metal Reduction Syndicate, Limited, Patricroft, near Manchester, read a paper on "The Manufacture of Aluminium." After a brief and interesting reference to the history of the metal, and the various improvements in the methods that have from time to time been adopted in its manufacture, the author gave a detailed description of the Hall process, which was patented in the United States in 1889, and which may be regarded at present as holding the field in the output of this comparatively new metal.

The Hall process consists of dissolving alumina in a fused bath of aluminium fluoride, and the fluoride of a metal more electro-positive than aluminium, and decomposing the alumina by passing an electric current through the bath. In practice the fluorides of sodium and calcium are usually added.

This process was first worked by the Pittsburgh Reduction Company, of Pittsburgh, Pa, in 1888, and in 1890 works were started in England by the Metal Reduction Syndicate, Limited, at Patricroft, near Manchester.

As the electrolytic processes as operated at present are very similar, the method of operating the Hall process may be taken as representative of the art at the present time.

Given an electric current of large volume and small tension, a number of carbon-lined steel pots are placed in series in the circuit, the pots forming the negative pole or cathode, and carbon rods attached to adjustable copper rods forming the positive pole or anode. The circuit being closed, by making contact between the carbon rods and the carbon lining of the pots, the current is turned on, and electrolyte added to each of the pots. The electrolyte is soon fused by the heat generated by the resistance of the pots to the passage of the current, and when sufficient bath has been fused alumina is added and the decomposition begins, the aluminium going to the bottom of the pot, which is the negative pole, and the oxygen going to the positive pole, combining with the carbon anode and escaping as carbonic acid gas. When the bath becomes exhausted of alumina or ore the resistance materially increases, as indicated by a meter attached to each pot, and more ore is added, thus restoring the normal working. From time to time, as metal accumulates in the bottom of the pot, it is either tapped off or ladled out, and run into molds as required. The electrolyte is unaffected by the current, the small loss which occurs being due to volatilization, and the process, once in operation, continues for months. The process is essentially a continuous one, working day and night, and the only limit of a run is the necessity for repairs to the machinery, and a holiday for the workmen.

The materials necessary for a pound of metal are:

2 lbs. anhydrous alumina,
$\frac{1}{10}$ lb. of electrolyte,
1 lb. of carbon.

The power required in this process is 18 electric H.P. per hour per pound of metal, although somewhat better results have been obtained. It will thus be seen that power is an important item in cost, and accounts for the exclusive use of water power on the continent, and the anticipated removal of the plant of the Pittsburgh Reduction Company to Niagara as soon as the turbines of the Niagara Falls Power Company are in place.

At present the electrolytic processes are the only ones used for the production of aluminium, and it does not seem probable that any better or cheaper methods will be discovered, although we are continually hearing of new processes, for which claims are made that the metal can be produced direct from clay or bauxite, at remarkably low cost. During the first few years of manufacture the price of aluminium ranged from 90*s.* to 60*s.* per pound, and from 1862 to 1886 the price was 35*s.* to 40*s.* per pound. Soon after the latter date the Aluminium Company, Limited, with works at Oldbury, came into the market with the metal at 20*s.* per pound. The price was soon lowered by the competition of the Alliance Aluminium Company, Limited, with works at Wallsend-on-Tyne. These two companies were soon forced out of the market by the companies at Neuhausen and Pittsburgh, which began selling the metal at about 8*s* per pound, and have since, owing to the larger consumption of the metal and the consequent decreased cost of production, been able so to reduce the selling price that it is now, volume for volume, but little more expensive than copper.

As the many valuable qualities of the metal have led to the belief that the price was the one obstacle to its extensive use, and as the compounds of the metal are found so universally and abundantly in nature, there has been no lack of investigators seeking to reduce aluminium by chemical means, but so far the sodium process has been the only one which would give the desired results. As noted above, it requires 3 tons of sodium for 1 ton of aluminium by either of the sodium processes, so it is easy to see why these processes are unable to compete.

As all clays contain a large percentage of alumina, it is a popular fallacy that aluminium is reduced from clay. The ore used is pure anhydrous alumina, which contains 52.94 per cent. of aluminium, and in practical working less than 2 tons of this material are required for 1 ton of metal, so that the efficiency as regards the ore is perfect.

The development of the electrolytic processes for making aluminium created a demand for pure alumina, and manufacturers have succeeded in supplying an article over 99 per cent. pure, the 1 per cent. being made up principally of water and silica. Pure carbon electrodes were necessary, and these are furnished with a fraction of 1 per cent. of ash. The result is that aluminium is made so that the entire product is over 99 per cent. pure, which is much better than the regular results obtained by the chemical processes. As the methods at present employed consist of the direct reduction of the oxide of the metal, it does not seem possible to have a more simple process, and not probable that a more complicated compound can be treated in a more economical manner. It may be inferred, therefore, that further cheapening of aluminium will depend upon the greater consumption of the metal and also upon cheaper power and materials, and the consequent decrease in the average general expenses with greater output. The present total output of pure aluminium is between 4 and 5 tons per day, which is more than the annual production up to 1886. This rapid increase in production has been due primarily to the decreased selling price, which encouraged consumers to make practical use of the metal. The present consumption may be graded into three classes, each of which takes about equal parts. These are iron and steel, brass and bronze, and pure metal.

The best testimonial is the continued use of the metal, and this is given by both iron and steel makers, and bronze founders. The properties of aluminium have been greatly exaggerated, and as greatly depreciated by many writers whose chief ability seemed to be their desire to appear in print. Notwithstanding the difficulties in perfecting a new process, and in introducing a new metal, aluminium has obtained a place among the metals of ordinary and daily use, and its position is continually being made more secure by a further appreciation of the uses to which it has been put successfully, and by new uses for which it is almost daily being introduced.

In using aluminium for steel the amount varies from one-third to three-quarters of a pound to 1 ton of steel, the result being sound ingots or castings free from blowholes, and a decrease in scrap and wasters. A further advantage is that a milder steel can be used for castings.

Wrought-iron castings have been made by the Mitis process, which depends upon the use of aluminium, but the variable results obtained have not led to the general use of this process, although it has not been abandoned.

The use of aluminium with cast iron produces sharper and cleaner castings, free from blowholes, and gives a more uniform casting. The iron is made softer, with less tendency to chill, part of the combined carbon being converted into graphite.

The amount of aluminium to be added to cast iron varies with the quality of the iron, but 1 to 2 lbs. to the ton of iron

gives good results. Too much aluminium is apt to be worse than none at all, and while it does useful work in cast and wrought iron and steel, its presence in the finished metal is not wanted.

This is not the case with the copper alloys, where aluminium is used to great advantage up to 10 per cent., beyond which the alloy becomes extremely hard and brittle, and loses its valuable qualities.

Aluminium is used with all the well-known brasses and bronzes with beneficial results in quantities up to 1 per cent. for deoxidizing or purifying the mixture, and its presence in the finished product is not detrimental. The result of these small quantities of aluminium is to produce cleaner and stronger castings.

While copper and aluminium alloy in any proportion, the useful bronzes do not contain over 10 per cent. of aluminium. These bronzes vary in strength and physical properties, but all of them can be forged hot or run into sand castings. Castings of 10 per cent. bronze are much like rolled mild steel, having a tensile strength of 26 tons to 28 tons per square inch, and an elongation in 2 in. of 25 per cent. to 30 per cent., but with a specific gravity of 7.5, while steel is 8.0. The 5 per cent. bronze is much softer and less strong, having a tensile strength of 17 tons to 18 tons per square inch, and an elongation of 60 per cent. to 70 per cent. in 2 in. Many different qualities of aluminium brass are made, but the best give a tensile strength from 30 tons to 35 tons per square inch, and 6 per cent. to 15 per cent. in 2 in., as required.

There are no copper alloys without aluminium which approach those containing aluminium, and from the physical properties noted above it will be seen that sand castings can be made equal to wrought-iron forgings, and with a material which is not consigned to an almost valueless scrap heap should an accident occur to the part. Increased tensile strength is obtained in the bronzes by the addition of silicon, but it is at the expense of elongation.

The pure metal is used as such for many different purposes in castings, sheets, tubes and wire. The malleability of the metal is such that it can be beaten into leaf, which has largely replaced silver leaf.

The shrinkage of pure metal is about $\frac{1}{4}$ in. to the foot, but castings are usually hardened, so as to get increased strength and to allow machining, and the shrinkage decreased.

The pure metal is quite soft, and in castings has a tensile strength of about 8 tons per square inch, while the hardened metal has a tensile strength of about 12 tons per square inch, and is as hard as gun-metal. Sheet and wire are much stronger than castings, depending on the amount of work done on the ingot metal. As no satisfactory solder has been found for aluminium, its uses are restricted to work that can be cast, stamped, spun, drawn or riveted, yet with this drawback the applications are numerous when there is a disposition to use the metal. Aluminium cooking utensils have found favor wherever tried, and are at present supplied by several makers.

The reading of the paper was followed by a short discussion, in the course of which Mr. Joseph Adamson, of Hyde, stated that he had been in correspondence with Captain Hunt, President of the Pittsburgh Reduction Company, with a view to the construction of a boiler of aluminium plates, and from the information he had received, it appears that the company are now producing plates of nearly pure aluminium, having a tensile strength of 50,000 lbs. per square inch, or if necessary 55,000 lbs., an elastic limit of 35,000 lbs., with a reduction of area of 20 per cent., or, in other words, with an elastic limit equal to that of good soft steel, which is three times as heavy. At present the Company are rolling plates up to 30 in. in width, and are prepared to supply ingots at a cost of about 2*s.* a pound, which can be rolled to the same size as ordinary steel boiler plates.

NOTES AND NEWS.

Railway Pension Fund of Holland.—Employés of State railways in Holland pay 1 per cent. of their wages to a pension fund, and during illness they receive two-thirds of their regular salary for four months.

English Dining-Cars.—The Midland Railway Company on trains from London to Glasgow has introduced the American system of dining-cars, but has bettered it by serving meals for both first and third-class passengers. The dinner, first-class, is 85 cents, third-class, 60 cents. Passengers who prefer may dine *a la carte*, ordering a cup of coffee for 5 cents, or tea with bread and butter for 10 cents, or a chop with bread and potatoes for 30 cents.

Railway Trains Run by Water-Power.—The announcement is made that the Canadian Pacific Railroad will adopt the trolley system for moving trains over two sections of the Rocky Mountains. The power will be developed from the waters which rush down the precipices and along the mountain sides.

A 2,000-Volt Electric Current.—Mr. Tesla has been making some brilliant experiments with high-voltage electric currents. It is stated that he has received through his hands currents at a potential of more than 200,000 volts, and there is a report that he expects to obtain a potential of 3,000,000 volts in some of his future experiments.

Rail to the Arctic Ocean.—A plan is on foot in Russia for building a railroad to the Arctic Ocean near the Swedish frontier. Starting from the Norwegian terminus of the Finnish railways, the road will be about 470 miles long. There are no serious engineering difficulties in the way of such a railway, and as it will be built on a cheap system much used in Finland, the cost will be in the neighborhood of $13,000,000.

Windmills for Electrical Lighting.—Some extensive experiments have been made lately with the use of windmills for electrical lighting, which have given promise of ultimately developing into something that will be successful and useful. The records of the United States Signal Service for the past 15 years show that wind may be relied upon to blow with sufficient velocity to drive a windmill with its average working capacity 8 hours out of every 24.

Illuminated Life Buoy.—Some trials have recently been made on board a German war vessel with an electric-light buoy. The buoy was thrown overboard when the vessel was proceeding at a speed of about 16 knots. For a few seconds it was lost in the eddy currents caused by the screws, but then reappeared. It is expected that the buoy will be found useful at night, and the experiments have resulted so successfully that it will probably be adopted by the German Navy.

Felling Trees by Electricity.—Trees are felled by electricity in the great forests of Galicia. For cutting comparatively soft wood the tool is in the form of an auger, which is mounted on a carriage and is moved to and fro and revolved at the same time by a small electric motor. As the cut deepens wedges are inserted to prevent the rift from closing, and when the tree is nearly cut through an ax or hand-saw is used to finish the work. In this way trees are felled very rapidly and with very little labor.

Test of Armor-Plate.—On May 15 there was a test of the armor-plate representing the turrets of the *Maine*, *Puritan*, and *Monadnock*, at the proving ground of the Bethlehem Iron Company. The plate tested was Harveyized and curved as it would go on the ship, with a thickness of 8 in. To cause the acceptance of the armor which it represented, it had to receive a blow from a 100-lb. 6-in. shot at 1,678 ft. per second without cracking, and a blow from another 6-in. shell having a striking velocity of 1,978 ft. per second, without being penetrated. These conditions were met. The penetration by each of the shots was from 2 to 3 in. As the projectiles were broken and the pieces remained welded in the holes, it was impossible to accurately measure the penetration, but the plate was not cracked. Captain Simpson, Chief of the Bureau of Naval Ordnance, who directed the details of the trial, ordered the 18-in. gun fired at the plate with 1,835 ft. velocity. A 250-lb. armor-piercing projectile was fired. The plate was cracked, but not penetrated by this blow.

A Peculiar London Railway Station.—A very queer railway station in London is that at Wapping, on the East London Line. Very few dwellers in other parts of London ever get out at Wapping, and thus they miss the singular beauties of the station. Its appearance is that of a huge caisson for some engineering works to which winding staircases have been added. Up the sides of the huge caisson the passengers crawl like flies on a window pane. The secret of its queer appearance is that it was originally the northern shaft of the famous Thames Tunnel, which Brunel built in 1843 at a cost of £468,000 ($2,277,522). It was very dangerous work, owing to the porous nature of the river bed, and the tunnel was long considered a masterpiece of engineering. It consists of two arched ways of 1,200 ft. long, 14 ft. wide, 16½ ft. high, and 16 ft. below the river. For a long time it was a popular excursion to go through the tunnel; but it never was a financial success, and in 1865 the East London Railway bought it for £200,000 ($973,300), or less than half its cost. The company now leases its lines to a syndicate of other companies, who use the tunnel as means of communication between the southern and northern railway systems.

A New Austrian Mitrailleuse.—The Austrian Government has definitely adopted Archduke Karl Salvator's automatic mitrailleuse. The arsenal trials proved highly satisfactory. One hundred of the guns have already been manufactured. The gun will not be used in field service, but only on the works of the fortresses. It is about half the weight of the Maxim machine gun, and has about the same firing rate. The barrel is incased in a water jacket. Twelve hundred rounds can be fired continuously without overheating the gun.

The Local Traffic of many roads is curiously managed by some one. It is not unusual to see two and three-car trains run by locomotives of 90,000 lbs. weight, and compound at that. As the mileage made by these engines on local trains is all charged in the annual report, it is not surprising that the compound engine is not so economical as expected. To a train despatcher or a round-house foreman anything is a locomotive, but some one should be in charge who understands the ins and outs of the matter. It is a great waste of power to use a horse to draw a baby-wagon.—*The Engineer.*

Petroleum for Fuel in Buenos Ayres.—Experiments have recently been made, it is said with success, on the Southern Railway of Buenos Ayres, in the use of petroleum on locomotives. Only two conditions are needed to make its use practicable: one is that other fuel relatively to petroleum should be dear, and that petroleum relatively to other fuel should be cheap. Under those conditions petroleum may be used economically, otherwise not.

Aluminium for Lithography.—The latest use to which aluminium is put, notes a technical journal, is in lithography, in which process it is claimed to possess many advantages over the stone now used while fulfilling all the requisite conditions. The only stone used for lithographing is found in Bavaria, and as the supply is diminishing the price is increasing. Moreover, it is very brittle, and being rigid can be used only on flat surfaces. Under a recently patented process, we are told, aluminium plates can be molded into forms for cylinder presses.

The First Iron Bridge.—The first iron bridge ever erected in the world, and which is in constant use at the present time, spans a little river in the county of Salop, on the railroad leading from Shrewsbury to Worcester, England. It was built in the year 1778, and is exactly 96 ft. in length. Total amount of iron used in construction, 378 tons. Stephenson, the great engineer, in writing concerning it, said: "When we consider the fact that the casting of iron was at that time in its infancy, we are convinced that unblushing audacity alone could conceive and carry into execution such an undertaking."—*St. Louis Republic.*

The Lake Steamer "North America."—A new steamer has recently been launched at the Globe Iron Works, Cleveland, for the Northern Steamship Company, and it is intended for service between Duluth and Buffalo. The general dimensions are as follows: Length over all, 383 ft.; length between perpendiculars, 360 ft.; breadth, molded, 44 ft.; depth, 26 ft.; depth to spar-deck, 34 ft. 5 in. The vessel has been built of mild steel throughout, with an inner bottom extending from the collision bulkhead forward to the afterpeak bulkhead aft. It has been built under special survey in order to obtain the highest classification in the United States standard rules.

This vessel is fitted with two vertical quadruple-expansion engines of 3,500 H.P. each, and with a total H.P. of 7,000 the vessel is expected to make an average speed of over 20 statute miles per hour. The boilers are the Belleville patent water-tube system; their nominal evaporative efficiency will give the main engines 7,000 H.P. and to the auxiliaries 500 H.P. more, with natural draft.

The electric-lighting plant is divided into three units; each unit consisting of a vertical, direct-connected, three-cylinder, triple-expansion engine and dynamo. The units are of 400—16 c. p. light capacity each, and develop an E. M. F. of 110 volts at 300 revolutions per minute. The state-rooms are lighted by 16 c. p. lamps, enclosed in ground glass globes; these lamps are lighted and extinguished by a switch placed adjacent to the berth. The main saloon is lighted by means of beautiful clusters, and in each panel running parallel with the state-rooms is placed a 16 c. p. lamp, enclosed in a ground glass globe. This same mode of lighting is followed in other departments; the style of fixtures, however, is somewhat varied.

A refrigerating apparatus will be supplied by the De La Vergne Refrigerating Machine Company, of New York. The machine which this Company supplies will be one of 8 tons refrigerating capacity every 24 hours, and is the model which this Company has especially designed for the purpose of going on board of ships.

Russian Armored Ship "Navarin."—The new Russian armored ship *Navarin*, launched in 1892 (but formally commenced October 8, 1890, in the anniversary of the famous Navarin sea battle), is now incorporated to the Russian fleet, and will have a crew of 579 men. The *Navarin* is, the *Peter the Great* being excluded, the largest ship in the Baltic fleet. The general dimensions are: Length, 338 ft.; breadth with armor-plates, 67 ft.; draft, 25 ft.; displacement, 9,476 tons. The whole ship is made of steel, the over deck (armored) also; only the planking of the overdeck and the lining of the armor are of wood. The armor extends 3 ft. above the water-line and 4 ft. below it. The thickness of armor in the middle part of the ship is 16 in.; the thickness of armored turrets is 12 in. There are two engines of 9,000 indicated H.P. Each engine has a counting apparatus and another apparatus which show the number of revolutions of the screws. The engines are provided with 12 cylindrical boilers, each with three furnaces. The ship has a steam winch and special vertical tubes for hoisting ashes from the ash-pits; and a steam steering-gear. Each engine contains a special evaporator to produce 2,200 galls. of water for boilers, and 1,900 gallons of fresh drinking-water a day. Each evaporator is provided with two apparatus of Totov, which gives 160 galls. of fresh water in an hour. The ventilation is very perfect. The military department has its own ventilation. The ship will be lighted by electricity. The auxiliary means of transport consists of two rowing long-boats, one half long-boat, two transport boats, two six-row-yawls, two steam long-boats; eleven in all. There is a single mast, very thick, of steel, only for giving signals. It has two side shrouds for hoisting the long-boats. Aloft the mast is armed with 10 rapid-fire guns. The armament consists of four giant 12 in. guns in two turrets, which are revolving and each contains two guns. They are the largest guns which have yet been made for the fortresses. Beside them the ship has eight 6-in. long-shot guns in the middle part, four each side; 12 rapid-fire guns on the stern, fore and middle, and 10 guns on the mas (as above said); and six Whitehead mining (torpedo) apparatus. Under this armed part of the ship the sailors' deck is placed. The captain's cabin takes its stern end (three rooms); the ward-room, bath, and bar are also situated here. The officers' ward-room and their cabins (state-rooms) are nearer to the center. Below this deck, and therefore, already under water, the rooms for the crew are designed. The armored ship *Navarin* was built by the Company of Franco-Russian Works in St. Petersburg. The hull alone cost $800,000. The engine was also made by the same Company, and cost $724,200, and with supplementary devices and evaporators, $770,800. Therefore the whole cost of the ship is $1,570,800. For comparison we will say that the armored ship *Peter the Great* has cost $3,000,000. The ship is not yet finished, and now she has gone from Newa Channel (in St. Petersburg) to Kronstadt, where she will receive the armament, and next year she will make a four months' cruise.

Underground Traction.—It is reported that the Metropolitan Traction Company, of New York, are to make a trial of the Siemans-Holske system of underground electric trolley line in New York. The system has been in use successfully for some time in Buda-Pesth on several lines, the first of which was laid down in July, 1889. This system is of the simplest construction, consisting of a conduit of pear-shaped section with two angle irons on one side, one for the in-going and the other for the return current. Sliding contact is made by means of shuttle-shaped sliders. Sixty cars are now run over the lines at Buda-Pesth, at an average speed of 12 miles an hour, and at a cost of 5½ cents per car mile. It would thus seem that this system has demonstrated its practicability at Buda-Pesth, and it remains to be seen if the conditions at New York would militate against its success there. It may be noted that in a report of the United States Consul at Buda-Pesth, made about a year ago, it was stated that the operation of the road was several times interrupted by unusually heavy falls of snow, though otherwise its operation was declared successful.

Spray in the Boiler.—A French engineer is reported to have designed a safety boiler of a somewhat novel character. It consists of a nest of horizontal tubes placed over the furnace. Into this nest water is injected in the form of spray, under which conditions it is instantaneously evaporated and superheated. "Solid" water, if one may use the term, is never admitted to the tubes. The evaporative power of the boiler is said to be remarkable, and it is stated that the tubes do not burn out.

Cost of Transmitting Power.—A comparison of the cost of transmitting power by various methods, as given in a French mining journal, presents the following data: 1. Comparative cost on 10 H.P. transmitted in 1,093 yds.—by cables,

1.77 per effective H.P. per hour; by electricity, 2.21; by hydraulics, 2.90; by compressed air, 2.98. 2. Comparative cost on 50 H.P. transmitted 1,093 yds.—by cables, 1.35 per effective H.P. per hour; by hydraulics, 1.87; by electricity, 2.07; by compressed air, 2.29. 3. Comparative cost on 10 effective H.P. transmitted 5,465 yds.—by electricity, 2.64 per effective H.P. per hour; by compressed air, 4.66; by cable, 4.69; by hydraulics, 5.29. 4. Comparative cost on 50 effective H.P. transmitted 5,465 yds.—by electricity, 2.34 per effective H.P. per hour; by cables, 2.65; by compressed air, 2.99; by hydraulics, 3.02. Steam was the prime mover used in each of the above instances, and it appears that, for long distances, electricity takes the lead in economy over all other systems. It has also, remarks the journal cited, a great advantage in the facility with which the power may be subdivided, and there appears to be no doubt that, in future coal mining, electricity will be much used for coal cutting, tunneling, pumping, hauling, etc.

The "Ericsson."—Considerable interest has been excited from the fact that a new torpedo boat, the *Ericsson*, was launched at Dubuque, 1,500 miles from the ocean. The designs for the hull and machinery and armament of this boat is 154 ft.; beam, 15½ ft.; draft, 4½ ft. Her displacement, normal, is 100 tons. She was designed to be longer and broader than the *Cushing*, without drawing so much water, and giving a greater speed. Completed, with slight changes in the design originally adopted, the *Ericsson* will compare with the *Cushing* as follows:

Ericsson: Length, 154 ft.; width, 15½ ft.; draft, 4½ ft.; indicated H.P., 2,500; 24 knots speed; displacement, 150 tons.

Cushing: Length, 138 ft.; width, 15 ft.; draft, 5½ ft.; 1,720 H.P.; 22 knots speed; displacement, 116 tons.

The general construction of the vessel is on the transverse system, and special attention has been given to the longitudinal strength and stiffness by the use of an intercostal vertical keel and broad, heavy stringer plates. At the bow a turtle-back deck works into and terminates in the conning tower. The armament of the vessel will consist of one fixed tube in the bow for firing the Howell torpedo; two diverging tubes on a training circle aft for the firing of the Whitehead torpedo, and four 1-pdr. rapid-firing guns. The turtle-back deck is also worked in a way to accommodate the torpedo tube and loading gear in the bow.

In the interior the boat is thoroughly modern, and that, of course, signifies something novel in a United States torpedo boat. The motive power was designed by the Bureau of Steam Engineering, and consists of two propelling engines (rights and lefts) of the vertical, inverted, direct-acting, quadruple-expansion type, with Thornycroft boilers, all placed in a common water-tight compartment. These are calculated to give a speed to the vessel of about 23 knots working at 412 revolutions a minute, and under a steam pressure of 250 lbs. to the square inch. The weight of all machinery, boilers, auxiliaries, and contained water, but exclusive of all stores, spare parts, steering-gear and capstan, is less than 52 tons. An electric plant for lighting the vessel by the incandescent system and for operating a search light has been provided. This plant is installed in the engine-room. Every means for the comfort of the officers and crew in the cramped quarters allotted to them has been employed, the fact being borne in mind that the radius of action of a torpedo boat is limited rather by the endurance of the people on board of her than by the amount of coal carried in the bunker. Two state-rooms are provided for the officers, and a large room, extending the entire width of the boat, containing four bunks, is provided for the petty officers. In the crew's quarters there are 12 bunks and a swinging space for four hammocks.

To make the special character of the *Ericsson* plain, a comparison with some of the latest built torpedo boats of the British and French navies is herewith given.

Vessels.	Length.	Displacement.	Speed.
Ericsson, U. S.	154 ft.	150 tons	24 knots.
Havock, H. M. S.	180 "	110 "	27 "
Conreur, France	149 "	114 "	23.5 "

Each one of these boats is intended to carry three quick-firing guns and to discharge torpedoes ahead and astern, or in practically any direction. It may be stated that of these three boats the *Conreur* is the only one now in commission.—*Providence Sunday Journal.*

Purdue University Laboratory.—President Smart, of Purdue University, has sent out a circular in which he announces the present state of affairs regarding the restoration of the laboratory which was burned on the 23d of January last. The announcement is made that the portion of the buildings which contained the foundry and wood-working shop has been repaired, and that the machines and tools are now in use by students. The machine-room, forge-room and steam engineering laboratory are in process of reconstruction. That portion of the plant which has excited the greatest interest among the railroad and engineering fraternity is the locomotive plant for testing locomotives, and every one will be glad to learn that this will not only be replaced, but that the facilities for doing work will be very greatly increased. This plant will be removed from the general laboratory to a new building especially designed to receive it, and the new plant will be larger and more complete than the original. Its parts will be made adjustable to receive any locomotive whatever; and in order that the whole may be available for testing the performances of locomotives from any part of the country, the building will be connected by a track with the Lake Erie & Western Railroad. A new traction dynamometer made up of the weighing portion of an Emery testing machine of 30,000 lbs. capacity has been especially designed, and is now being built by Messrs. William Sellers & Company. The possession of this fine piece of apparatus will secure great accuracy in the determination of draw-bar stresses, which is one of the important elements in the performance of a locomotive. The importance of the locomotive work that originated at Purdue has been especially recognized. Before the fire there was a single locomotive; now, by the addition of the Baldwin working model, there will be in effect two; then the locomotive was in the general laboratory, now it is to occupy an annex by itself; then it was an isolated plant remote from railroads, now the annex is in track connection with the railroads of the country; then the plant was arranged to test the Purdue locomotive *Schenectady* only, now ample provision has been made for testing any locomotive that may be ordered. Certainly the officers and faculty of Purdue University are to be congratulated upon the prompt response for assistance which they have received and the cheerfulness with which large sums of money have been made available for the restoration of this most valuable laboratory.

Projected Line up the Jungfrau.—The Swiss Department of Finance has received from the well-known financier of Zurich, Guyler Zeller, a request for the concession for a road of a new design up the Jungfrau. We know that there are already three old projects in existence at which the point of departure is put in the upper valley of the Lauterbrunner. The others are Messrs. Coechlin, formerly Engineer of the Eiffel establishment in Paris; Colonel Locher, and Engineer Trautweiller, but up to the present time none of these projects have any chance of being executed. The new project will start from Scherdegg Station, which is the highest point reached from the railroad Wengeralp that was opened to traffic in 1893. Starting from Scherdegg, the route turns to the west, passes along the side of Fallboden, and abuts directly at the foot of the Eiger glacier, then toward the east and afterward to the south into a tunnel, in order to avoid the massive Eiger, and reaches Eiger Station, located at an altitude of 10,171 ft., and is built in under open cut. Then the line turns to the right, still in the tunnel, toward Moench and the neck of the Jungfrau, which will be pierced at a distance of 345 ft. from the crest; it then turns in a spiral up through the massive rock of the Jungfrau itself to emerge on a small plateau located 4,593 ft. above the level of the sea. This plateau is 213½ ft. from the summit, and is not covered with snow in the summer-time. Finally, the crest is reached by means of an elevator of 213½ ft. in height, composed of two concentric tubes of iron; the interior to be enclosed. The elevator proper and the annular space between them is provided with a stairway. At the center of the line between Scherdegg and Eiger stations, as well as between Eiger and the Jungfrau, stopping and crossing places are located. The gauge of the track is to be 2 ft. 7½ in. The minimum radius of curves will be 197 ft. and the steepest grade will be 25 per cent. The line in the open will have a length of 7,054 ft., the tunnels, 33,629 ft.; curves represent 26 per cent. of the total length of line. In variations from this project the figures given above are respectively 820 ft., 27,560 ft., and the total length is 6.77 miles instead of 7.7 miles of the original project. As for motive power, they propose to use electricity. The tunnels are to be lighted with electric light; their section will be 129 sq. ft. The water power will be taken at Tunnelbach or at one of the two Lutschines. The line will first be built up to Eiger station, and this will necessitate further service and a delay of two years. During the following two years the second section of the line will be built. The estimated outlay is, for the main line, $1,425,000 in round numbers, of which $972,040 is for substructure, $71,820 for superstructure, and $115,900 for rolling stock from the elevator for the State lines; the cost of construction will rise to $1,254,000, and an estimated dividend is placed at 5.16 per cent.

Cotton Mills in Egypt.—The success which has attended the establishment of mills in the United States and other countries in the neighborhood of cotton fields has suggested to capitalists the practicability of trying the experiment in Egypt of fabricating the native cotton to clothe the people of the country. A company is forming with English and local capital to establish at Cairo a factory of about 18,000 ring spindles and 500 looms of the newest and most approved make; and if the venture prospers it is proposed to establish mills at Alexandria and other points. The Cairo factory will be under English management, and will be equal in many respects, it is promised, to the most modern and best-equipped factories in England. An authorization for the undertaking has been granted by the Egyptian Government, and assurances have been given that every encouragement will be afforded the new industry. The demand for cotton cloth in Egypt is large and constantly increasing, while Cairo is a distributing point not only for Upper and Lower Egypt, but also for the supply of cotton goods to the adjacent countries. Egyptian cotton, both brown and white, is well known to be of excellent quality, and can be delivered in Cairo at a much lower price than in England; the rate of wages is also much lower. The Egyptian workmen are clever and easily taught, and the supply of suitable labor is ample. In addition to the cost of freight and forwarding expenses on all goods coming into Egypt from Europe, there is a duty of about 8 per cent. ad valorem payable on all imported goods. These charges will be saved on the home-made production as well as the original 1 per cent. paid on the cotton when it was shipped from Egypt. This saving, coupled with the suitability of the climate and the abundance of good labor, furnishes evidence of the practicability of the undertaking. The site of the proposed factory is in the immediate vicinity of the Nile, whence water for all purposes will be obtained, and the river can also be used for the conveyance of coal and cotton to the mill. A railway runs near the factory, and a branch line of rails can be extended into the grounds, thus giving direct communication with all the railways in the country. With a population of between 7,000,000 and 8,000,000 people, in a climate where garments of wool are worn but a few months in the year, the project theoretically has much to commend it; and with intelligent and prudent management this venture may be the precursor of a movement that will make the people of Egypt independent of England for their fabrics, for Manchester's looms now supply more than 90 per cent. of the textiles coming into the country. The enterprise should render its projectors a fair measure of profit and at the same time give the Egyptians the advantage of a saving in the cost of their clothing, and illustrate for the benefit of other nations whether Egypt offers a medium for the profitable employment of capital in cotton working.—*Consular Reports.*

An Ancient Telephone.—It is a pretty widely known fact that as early as 1667 the English physicist, Robert Hooke, described the transmission of sound to a very considerable distance. He says that, by the help of a tightly-drawn wire, which even might be bent in many angles, sound might be propagated to a long distance, and with a rapidity which, though inferior to that of light, was, at any rate, infinitely superior to that of sound in the open air. It is a most curious fact, and one which is not so generally known, that Jacob Christoph Von Grimmelshausen, a German author of the seventeenth century, in the first chapter of the third book of his celebrated novel, "Simplicius Simplicissimus," mentions an instrument which, according to his description, not only corresponds to Robert Hooke's apparatus, but leads to the assumption of the existence of a contrivance at the time of the Thirty Years' War very similar to our present telephone. The passage from the book reads literally as follows: "I was, as already mentioned, so eager to gain honor and renown, that I could not sleep while all this was passing through my head. And when I had such fancies, and lay awake many a night thinking how I might contrive new finds and stratagems, I had very curious notions; consequently I bethought myself of an instrument with which I could on a calm night hear a trumpet being blown at three hours' distance, and a horse neighing and a dog barking at two hours', and a man talking at one hour's distance. In the daytime the instrument was not so useful to me unless it were in a quiet place, because one would have heard the horses and the cattle down to the least bird in the air, or frog in the water, all together, so that one would not have understood one in consequence of the noise of the other. Now, I know quite well that there are people at this very hour who do not believe me; but, whether they believe me or not, it is the truth. I undertake, by means of an instrument invented by me, to recognize at night by his voice a man who does not speak louder than his usual custom. And no one would believe me of those who saw with their own eyes how I used the aforesaid instrument, and when I said to them, 'I hear horsemen galloping, for the horses are shod,' or 'I hear peasants, for the men go barefooted'; then, 'there goes a herd of cattle, for I hear sheep bleating, bulls bellowing, and pigs grunting, and so forth.' My own comrades at first took these speeches for 'fibs,' but when they found in reality that I was always speaking the truth, then they called it witchcraft taught me secretly by the devil's own mother. I am of opinion that if I had taught this science openly I should have become very popular, because it would have proved of great advantage to those engaged in war, especially in sieges." This is what Grimmelshausen says about his "far-hearing instrument," to which must be accredited a certain resemblance with the present telephone.—*Machinery.*

Engineering Feat at Holloway.—In the ordinary performance of the daily work at a terminal station the coaches which arrive from their journeys have to be stored, cleaned and transferred from the arrival side to the departure side of the station. At King's Cross the Great Northern Railway has always done some of this work in the terminus itself, but the recent erection within it of two additional platforms for main lines service has necessitated an entirely new storage ground at Holloway. The empty coaches will be run up to it by an extra line of railway, but between the site itself and the line of rails by which the coaches have to be returned to King's Cross there are eight intervening roads of main line, for goods and slow and fast passenger service, upon which the traffic is so busy that, between midnight of one day and midnight of the next day, there is only one free time of a quarter hour—namely, between 1.15 A.M. and 1.30 A.M.—when anything could pass across without interruption from one side of the railway to the other. Nothing could be done on the surface without extreme danger, and nothing at all in a fog. To construct a passage under the eight main lines had, therefore, to be done under circumstances which have no actual parallel. The Canonbury Railway has for years dived under the Great Northern at this point, and another subway has now been made alongside of it under the eight main lines referred to.

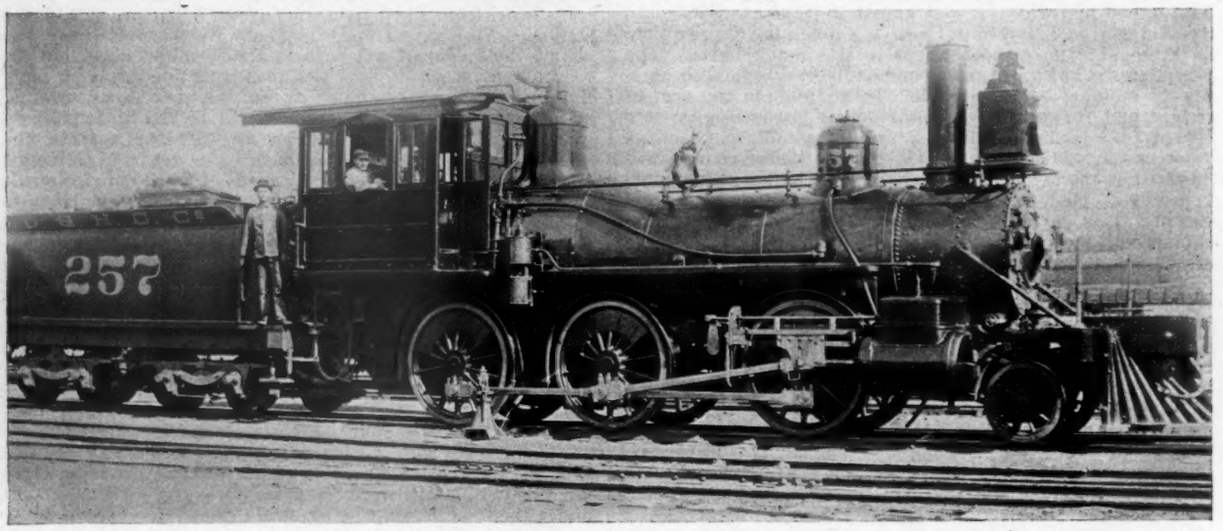
The problem was how to effect this without any disturbance of the service runnings of the trains. First the eight double lines of rails were temporarily secured by timbers put under them—a roofing being thus formed for excavating a working trench below. The abutment wall of the Canonbury Railway was next strengthened, and at the required distance away from it a second wall was built underground. On the east side of the main lines was a shunting-ground with numerous points and crossings. This constituted the *crux* of the undertaking, because only in the intervals of the cessation of traffic on Sundays could this tract be cleared and the rails replaced. Steps were accordingly taken by erecting at the side of the railway embankment a staging of piles upon which the whole main portion of the new steel skew-bridge—105 ft. long and 26 ft. wide, with end girders on the skew 60 ft. in span—could be riveted up and completely framed together. On each side of the staging was laid a double line of rails, and on each of them was made up a train of four six-wheeled trolleys, kept at distances of 35 ft. apart by horizontal struts of timber. Each of these trolleys was fitted with two hydraulic presses, the rams of which were raised up to the point, so that the under side of the two lateral girders of the bridge, as they rested upon the rams, would be a few inches above the tops of the two abutment walls, which were ultimately to carry this portion of the bridge. When all was completed, three crab-winches were attached to the ropes and pulleys, and worked by four men each. The bridge section, weighing 200 tons, was thus moved slowly forward, the rails and crossings being pulled up and the ground dug out for about 3 ft. in depth before it. Thus a way was cleared for the bridge, which is a flat box-girder construction about 2 ft. thick, to pass onward. When the steel structure had been brought to its final position, the hydraulic rams were lowered until the bridge rested firmly and permanently on the two subterranean abutments. The trains of trolleys were then withdrawn back to the timber staging to be dismantled and removed. The core of earth, or "dumpling," which remains has to be removed at leisure, and then the new line will be free for the service of the empty coaches. In both the structural arrangements and in the moving of the ponderous mass the intricacy of the skew form was intensified by its being also on the curve; but, notwithstanding the difficulties of construction and of moving into place, the designs had been so accurate, and the working to span so true, that the massive structure was brought without any adjustment into a perfect fit with the contiguous line of roadway. To fulfill the whole engagement, eight smaller sections of the bridge were required to be

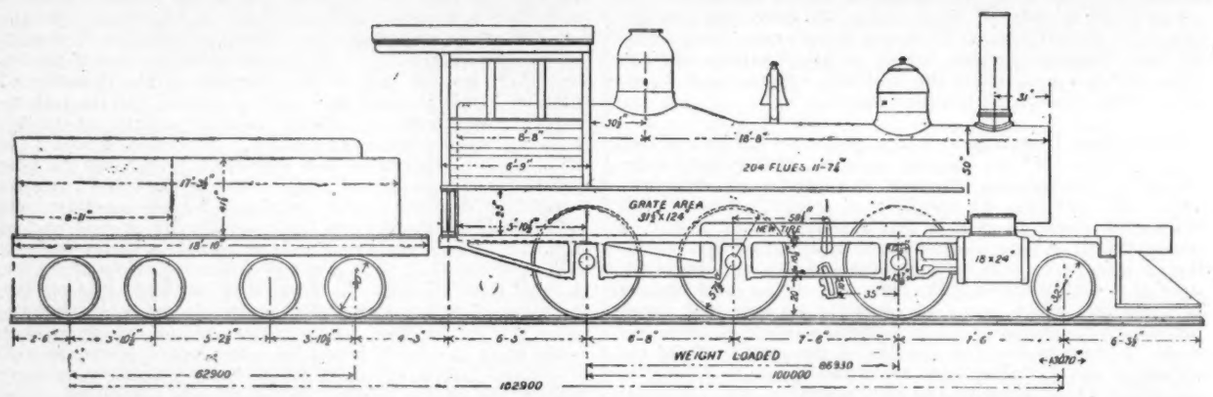
put together on the west side of the Great Northern Embankment, and to be hauled over the main lines into position on succeeding Sundays.—*Indian Engineering.*

STANDARD MOGUL FREIGHT LOCOMOTIVE OF THE DELAWARE & HUDSON CANAL COMPANY.

THE Delaware & Hudson Canal Company have a number of mogul locomotives that have been built at the Oneonta shops under the direction of Mr. R. C. Blackall, Superintendent of Machinery, that are doing most excellent service, engravings of which are shown in this connection. Some of these engines have been in service for three years, and have not been in the shops since they were built. They are rated as first-class freight moguls, but have been used on some of the fastest passenger trains, and where, in many places on the road, it is necessary to run at the rate of 60 miles per hour in order to maintain schedule time. This engine, No. 257, has never yet failed to meet the requirements. The freight locomotives on this road are loaded very heavily, so much so that they have to be run "down in the corner" in order to get over the road, and the motive-power department naturally feel that when an engine can be kept out of shop for three years under such treatment as this it is well built. The following are the principal dimensions of the engine:

Kind of fuel used	Anthracite coal.
Gauge of road	4′ 8½″
Total weight of locomotive in working order, including two men, actual weight	100,800 lbs.
Weight of loaded engine and tender	158,000 "
Total weight on driving-wheels	886,930 "
" wheel base	21′ 8¾″
Distance between center of front and back driving-wheels	14′ 2″
" from center of main driving-wheels to center of cylinders	11′ 10″
Distance from center of main driving-wheels to center of back driving-wheels	6′ 8″
Length of main connecting-rod from center to centre of journals	7′ 8¾″
Transverse distance from the center of one cylinder to the center of the other	6′ 10¼″
Diameter of cylinder and stroke of piston	18″ × 24″
Horizontal thickness of piston over piston-head and follower plate	5⅛″
Kind of piston packing	Cast-iron rings.
Diameter of piston-rod	3″
Size of steam-port	1¼″ × 16″ — 1″ bridge in center of port.
" " exhaust port	2⅛″ × 16″ — 1″ bridge in center of port.
Greatest travel of slide valves	5¼″
Outside lap of valve	⅝″
Inside lap of slide valves	Line and line
Lead of slide valves in full stroke	1/16″
Throw of upper end of reverse lever from full gear forward to full gear backward, measured on the chord of the arc of its throw	54⅛″





STANDARD MOGUL FREIGHT ENGINE OF THE DELAWARE & HUDSON CANAL COMPANY'S RAILROAD.

Sectional area of opening in each steam-pipe connected with cylinders	14.18″
Diameter of driving-wheels outside of tires	57⅜″
" " " centers	50″
" " front truck-wheels	32″
Thickness of driving-wheel tires	3½″
Size of main driving-axle journal, diameter and length	7″ × 9″
" " other " " " " "	7″ × 9½″
" " truck axle journals, diameter and length	5″ × 9″
" " main crank-pin journals, diameter and length	4″ × 4″
" " coupling-rod journals, diameter and length, front and back	2¾″ × 3″
Size of coupling-rod journals, diameter and length, main	3″ × 4½″
Length of driving-springs, measured from center to center of hangers	32″
Description of boiler	Wagon top.
Inside diameter of smallest boiler ring	50″
Outside " " " " sheet	51″
Driving-wheel base	14′ 1¾″
Height from rail to top of stack	14′ 4″
Material of barrel of boiler	Otis steel.
Thickness of plates in barrel of boiler	½″
Kind of horizontal seams	Double riveted lap with welt.
" " circumferential seams	Double riveted lapped.

Material of tubes	Iron.
Number of tubes	208
Diameter of tubes, outside	2"
Distance between center of tubes	2¾"
Length of tubes over tube plates	11′ 9¼"
" " fire-box, bottom	124"
" " " top	128"
Width " " " bottom	32"
" " " top	42½"
Depth " " back end	48"
" " " front end	60"
Water space, side of fire-box	3½"
" " back of fire-box	3½"
" " front of fire-box	3½"
Material of outside shell of fire-box	Otis steel.
Thickness of plates of outside shell of fire-box	7/16"
Material of inside fire-box	Otis steel.
Thickness of plates inside of fire-box	⅜" sides.
" " " back end of fire-box	7/16"
" " crown-plate	⅜"
Material of tube-plates	Otis steel.
Thickness of front tube-plates	½"
" " back tube-plates	9/16"
How crown-plate is stayed	Riveted to crown bars.
Diameter of dome	27½" inside.
Height of dome	25"
Maximum working pressure per sq. in.	145
Kind of grate	Water grate of 2" tubing, extra heavy.
Width of bars (or diameter of tubes of water grates) out	2"
" " " " " " " " " " inside	1⅜"
" " opening between bars (or tubes)	1"
Grate surface	27½ sq. ft.
Heating surface in fire-box	129 "
" " of the inside of tubes	190 "
Total heating surface	319 "
Kind of blast nozzle, single or double	Double.
Diameter of blast nozzle	2⅜"
Smallest inside diameter of chimney	16"
Height from top of rails to top of chimney	13′ 7"
" " " " " " center of boiler	6′ 8"
Weight of tender empty	35,700 lbs.
Number of wheels under tender	8
Diameter of tender-wheels	30"
Size of journals of tender axles, diameter and length	3¾" × 7"
Total wheel-base of tender	12′ 11½"
Distance from center to center of truck wheels of tender	3′ 10½"
" " " " " " tender truck	9′ 1"
Water capacity of tank (in gallons of 231 cu. in.)	3,300 galls.
Coal capacity of tender or fuel-bin	5½ tons.
Total wheel-base of engine and tender	45′ 3"
" length of engine and tender over all	55′
Thickness of frames	4"
Width over frames	4′ 2⅜"
Length of parallel rod, center to center, front	90"
" " " " " " back	91¾"
Throw of eccentric	5"
Radius of links	50½"

THE RECIPROCATING PARTS OF A LOCOMOTIVE.

By F. J. Cole, Mechanical Engineer, Baltimore & Ohio Railroad.

(*Continued from page* 204.)

The influence of the weight and velocity of the reciprocating parts in a high-speed engine has much to do with its steadiness of motion. The uneven force exerted on the crank-pin, caused by cutting off steam at high pressure early in the stroke, is largely corrected and made uniform by the acceleration required at the commencement of and retardation at the latter part of the stroke.

The subject can be best considered by plotting the curves of variation of tractive force upon the same diagram, on which the curves of fluctuation in weights borne by the driving-wheels, caused by the vertical influence of the counterweight, are shown.

In considering this subject it is first necessary to consider the relation that the movement of the piston bears to the circumferential velocity of the crank. Twice in one revolution the piston comes to a state of rest, on passing a dead center, and equals, about the middle of the stroke, the velocity of the crank, which it is assumed is revolving with a uniform motion. During the first part of the stroke the piston acquires an accelerated velocity, until it reaches the middle, when it moves at the same speed as the crank, and then gradually diminishes until the dead center is reached, after a movement of 180°.

"In order to produce the acceleration, pressure must be applied during the first half of the stroke, and the necessity of bringing the reciprocating parts to a state of rest causes the same amount of pressure to reappear during the second half of the stroke in corresponding ratios upon the crank-pin." *

"The pressure required to accelerate the reciprocating parts equals, when the crank is on the dead center, the entire centrifugal force, and gradually diminishes until at the middle of the stroke it becomes zero, being a minus quantity to be deducted from the force applied by the steam to the piston.

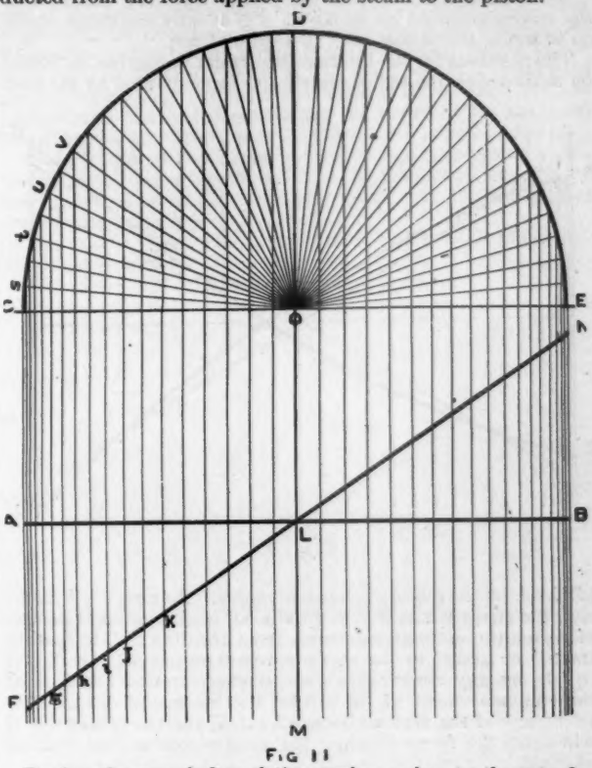


Fig. 11

During the remainder of the stroke, owing to the retardation of piston speed, the same force is gradually given out until it equals again at dead center the centrifugal force, being a plus quantity to be added to the steam pressure.

If the force required for acceleration be calculated for the different crank angles, assuming the connecting-rod to be of infinite length and the pressures marked off on vertical lines corresponding to the different positions of crank, it will be found by joining all these points that a straight line is produced.

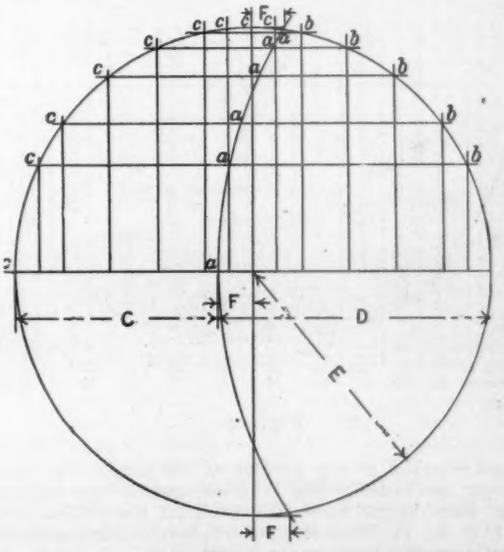


Fig. 12.

Make the line *A B*, fig. 11, equal the piston stroke, and *C D E* the path of the crank, *s t u v*, etc., the crank angles. With the same scale as the indicator diagram make *F* equal, at the commencement of the stroke, to the entire centrifugal force of the reciprocating parts, divided by the area of the piston $\frac{\text{Cent. } F}{\text{area piston}}$. *L*, the middle of stroke, where the speed of

* Arthur Rigg, "Treatise on the Steam Engine."

piston equals the circumferential velocity of crank (no force is absorbed or given out), is located at the intersection of *A B* and *L D*.

N B equals *A F*, for the reason that the force absorbed at the commencement of stroke at *A F* exactly reappears again on bringing the piston, etc., to a state of rest.

The positions for the intermediate crank angles can be found by multiplying the entire centrifugal force divided by the area

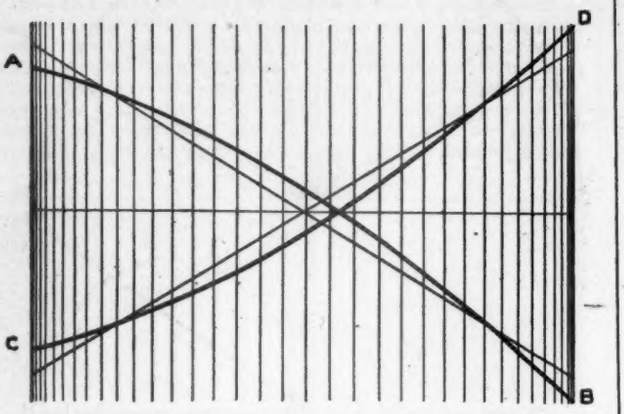


Fig. 13

of piston by the *cosine* of the crank angle. Joining *F g h i J K*, etc., the straight line *F N* is produced, giving at any position of piston the amount measured from the line *A B* to be subtracted or added to the steam pressure on piston. Or if *C O* equals, by any convenient scale, the acceleration required at the commencement of the stroke, the horizontal distance between any of the vertical lines, *g h i J K*, and the center line *O* will equal the force required for acceleration at that position of crank.

It is, therefore, only necessary, in calculating the amount of acceleration required with a rod of infinite length, to make the positions *F* and *N* equal to the entire acceleration required, and joining the same by a straight, diagonal line to obtain the

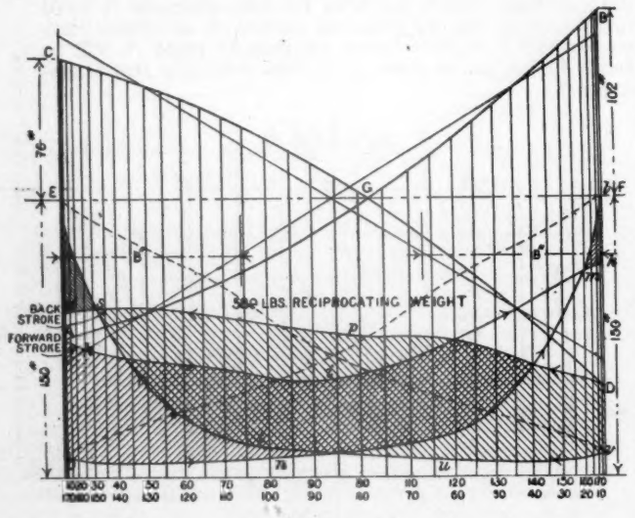


Fig. 14.

amount required at any position of the stroke. In practice, however, as the disturbing influence caused by a connecting-rod of finite length must be considered, the vertical straight line *D O*, fig. 11, becomes a curved line, varying according to the ratio existing between the length of the rod and the crank.

Make the radius *E*, fig. 12, equal on the same scale as the indicator diagram, the acceleration required at the commencement of the stroke, and divide by the vertical lines into 10 equal spaces, the two end spaces in each side being subdivided. Join these perpendicular by horizontal lines, where they intersect the circumference at the points *c c c* and *b b b*. Make *F* at the center line and the top and bottom of circle equal the total acceleration required divided by the ratio of main rod to crank. Find a radius that will intersect the three points thus found, and use it, instead of the straight line *D O*, fig. 11, from which to measure the ordinates.

The force required for reciprocation at any point of the stroke can be accurately determined, and the disturbing influence caused by a main rod of some given length, by the construction of a diagram similar to fig. 13. The ordinates just found in fig. 12 are measured off and plotted on corresponding vertical lines in fig. 13. These points when joined will produce parabolas *A B* and *C D*.

Having considered the manner of constructing the diagrams representing the force absorbed or given out at different points of the stroke, it will be necessary now to show their relation to the indicator diagram, under different conditions, weight

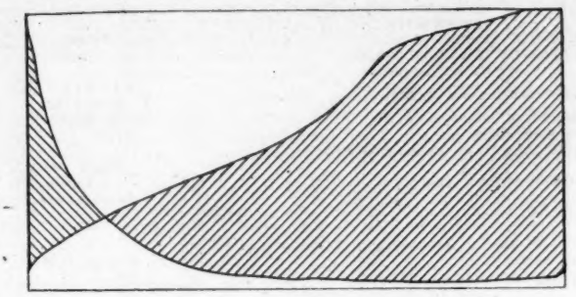


Fig. 15

of reciprocating parts, and speed. Fig. 14 shows an indicator diagram taken from the same class of engine previously used as illustrating the vertical effect of counterbalance on the track. Speed, 60 miles per hour; boiler pressure, 160 lbs.; cut-off, 8 in., or one-third of stroke; length of main rod, 85$\frac{1}{16}$ in. The upper dotted lines represent the uncorrected card as it leaves the indicator. Weight of reciprocating parts, 589 lbs., which are the actual weights now in service on the engine.

In order to obtain a clear understanding of the diagram, it is first necessary to imagine the indicator card as it really exists and not as it is usually shown, in which each card for front or back ends of cylinder represents the varying pressure for that end and not the actual thrust on the piston, which is the steam line of one end, combined with the exhaust and back pressure of the other, as shown in fig. 15. A diagram of this

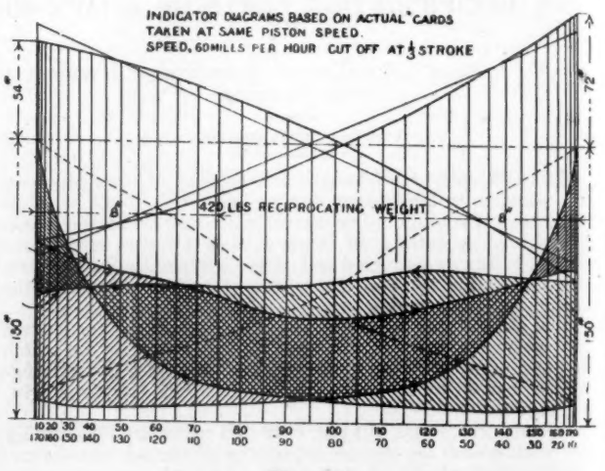

INDICATOR DIAGRAMS BASED ON ACTUAL CARDS
TAKEN AT SAME PISTON SPEED.
SPEED, 60 MILES PER HOUR CUT OFF AT 1/3 STROKE
420 LBS RECIPROCATING WEIGHT

Fig. 16.

kind shows at a glance the force exerted on the piston and the opposing force acting against it, at what point they equalize each other, and the exact relation that one bears to the other. In fig. 14 the curved line *A B* represents the influence of the reciprocating parts and angularity of main rod for the forward stroke, and *C D* correspondingly for the back stroke.

Commencing with the forward stroke indicator card, the distance which the curved line *A B* is above or below the horizontal line *E F* (representing the initial pressure) must be taken from or added to the indicator diagram measured on the vertical lines. The irregular curved line *h j k* is thus produced, representing the actual force exerted on the crank-pin. The opposing force or back pressure on the other side of the piston is represented by the curved line *l m n o*. The effec-

tive pressure, then, for any position of stroke would be the distance measured on any vertical line bounded by these curved lines, and shown in diagram by cross-hatching.

It will be observed that the small triangular space *l m k* represents back pressure or minus quantities.

The card for back stroke is corrected in a similar manner, commencing at *D*, the steam pressure being represented by the line *D p r*. The triangular space *D G l* being deduced from the steam card, and *E G C* being the space above the horizontal line, added to the card. The back pressure on the back stroke is shown by the irregular curved line *E s t u v*. The small triangle *E s r* represents the back pressure or minus quantity. The most noticeable feature about this diagram, fig. 14, is that the correction for the acceleration or retardation of the reciprocating parts exactly reverses the conditions shown by the primary indicator card. The pressure on crank-pin is much less at the commencement of the stroke than at the completion, showing clearly that the weights of piston, etc., viewed entirely from a stationary engine standpoint, and without reference to any injurious effect on the track, are too heavy for the speed, steam pressure, etc.; also that the smooth running of the engine at this velocity would be improved by their reduction in weight. Fig. 16 represents the effect of the reciprocating parts weighing 420 lbs., constructed as previously shown in figs. 4, 5, 6 and 7, all other conditions being similar to fig. 14. This shows almost the same pressure on the crank-pin at the commencement and completion of the stroke, and represents very nearly the most suitable weight at this speed for correcting the irregular steam pressure, and modifying it so that an almost uniform pressure on the crank-pin is produced.

Turning again to the curves of tractive force plotted out at the bottom of fig. 3, the effect of the light and heavy reciprocating parts, and the relation existing between the vertical

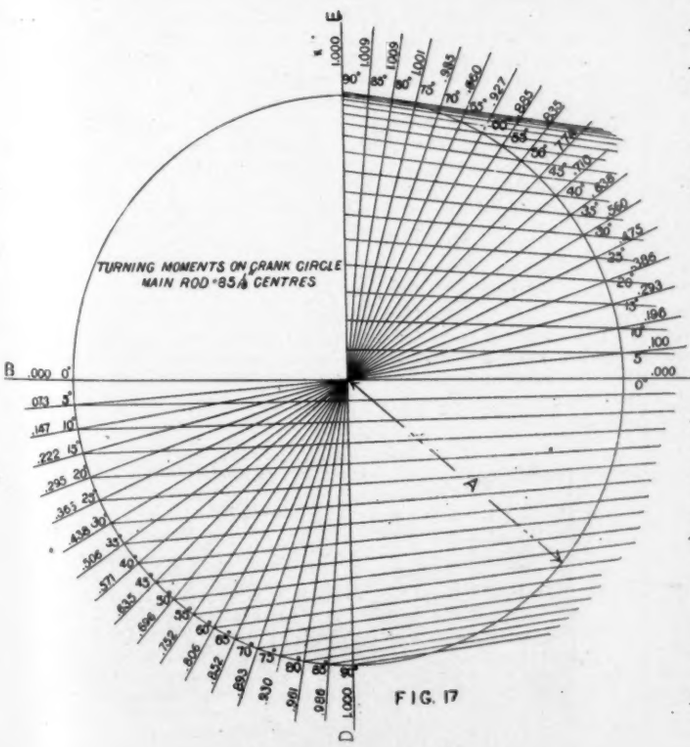


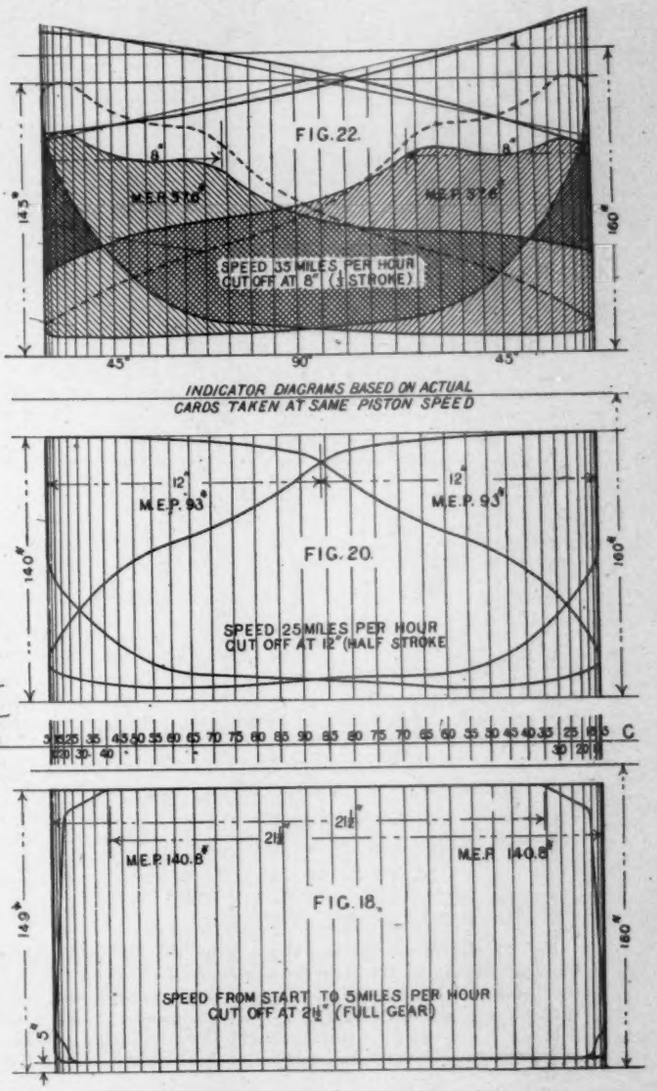
FIG. 17

effect on track of same, is clearly shown. The effect of the heavy parts (589 lbs) is shown in full lines, the right and left sides separately in lighter, and the combined effect of both sides in heavier lines, while the curves of the light parts (420 lbs.) are shown in the dotted lines. The manner of plotting these curves is as follows: The turning moments on crank circle for each 5° of crank angle are obtained by constructing a diagram, fig. 17, and calculating therefrom the coefficient for each angle.

Take any convenient scale and make *A* equal to the length of crank, *B C* the horizontal center line prolonged sufficiently to the right to take in the length of the main rod, and *D E* the vertical center line; divide the two diagonal quarters by radial lines 5° apart. Then, with an opening of dividers equaling the length of the main rod from center to center (85 1/16 in.), if the point is stopped successively at the intersection of the radial and circumferential lines, the exact position of the piston for each 5° of crank movement will be accurately located on the horizontal line *B C*. The varying turning moments, due to the angularity of the rod, and the different positions of the crank, are obtained by calculating the ratio existing between the radius of the crank and the vertical height of the lines representing the center of the main rod for the forward stroke, where they intersect the vertical line *D E*. For the back stroke, the lines representing the center of the main rod must be prolonged until they intersect the vertical line *D E*.

If the length of the crank is divided into a thousand parts, the vertical height, measured from the horizontal line *B C* by the scale, will equal the coefficient marked on the radial lines outside the periphery of the circle.

The tractive force, then, for one side at each 5° can be obtained as follows:



R = radius of wheel;
L = " " crank;
C = coefficient for each 5° of crank angle;
E = effective pressure from diagram at each 5°;
T = tractive force for one side at each 5°;

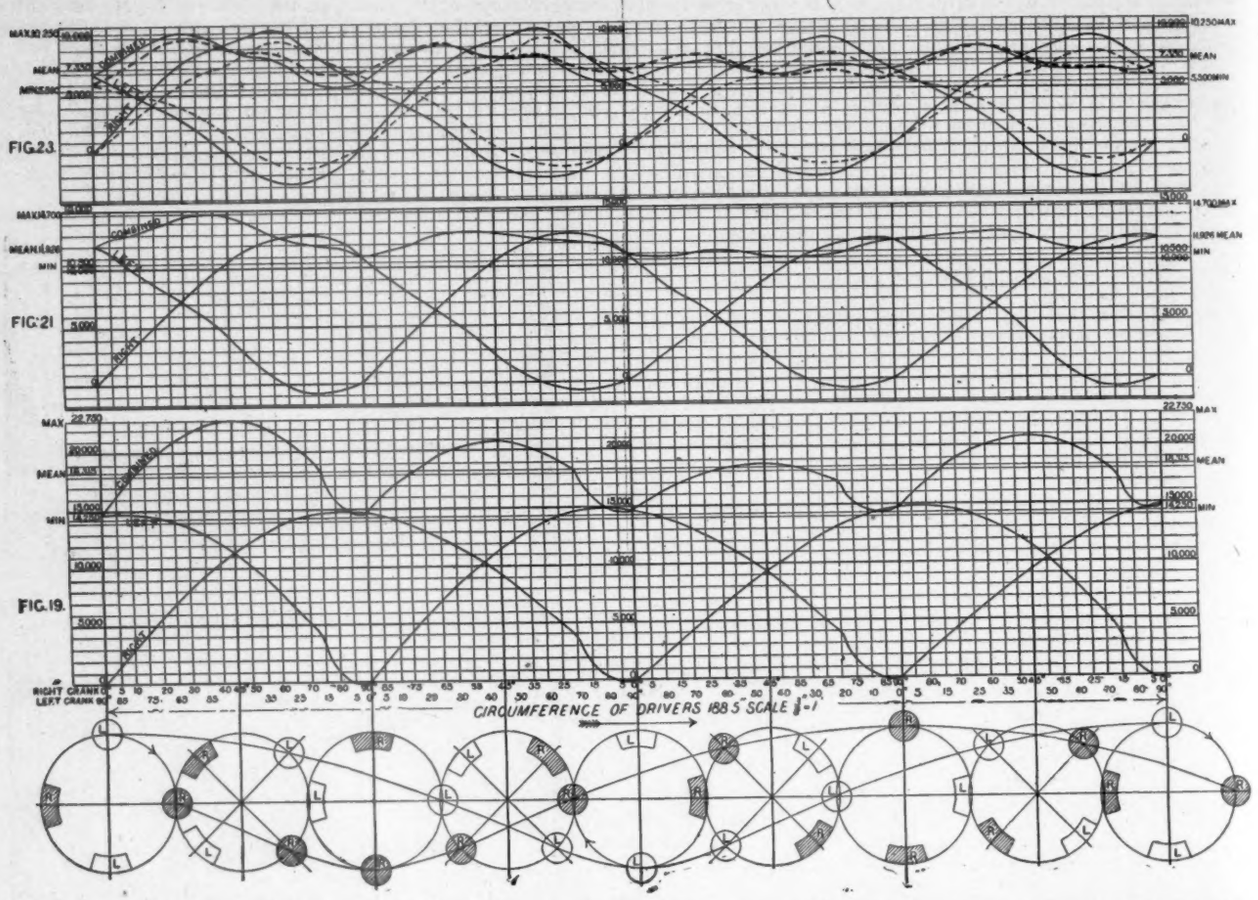
$$T = \frac{C \times L \times E}{R} = \frac{C \times 12 \times E}{30} = \frac{C \times E}{2.5}.$$

These curves are located for each side and combined in a similar manner to the curves for vertical effect.

The fluctuations in the tractive force can be best shown by digressing for a few moments, and considering only the tractive force at starting and at slow speeds without reference to the reciprocating parts.

An indicator card for the same class of engine speed, start to 5 miles per hour with a cut-off of 21½ in. (full gear), is shown in fig. 18, with corresponding curves shown in fig. 19. This gives a mean tractive force of 18.315 lbs.—minimum, 14,250 lbs., and maximum, 22,750 lbs.; the latter equaling 31 per cent. of the total weight on the drivers, and the mean

obtainable from an engine of the same dimensions in ordinary mixed service—speed, 30 miles per hour; cut-off, 8 in. (one-third stroke). Fig. 25 gives the curves for tractive force—maximum, 11,700 lbs.; minimum, 7,400 lbs.; mean, 9,580 lbs.—showing an increase on the mean effect of 1,730 lbs., or 23.8 per cent.



equaling 25.3 per cent. of the same. Taking the mean effective pressure at 140.8 lbs., as shown on the diagram, and calculating the tractive force by the usual formula,

$$\frac{D^2 \times L \times 140.8}{W} = 18{,}247 \text{ lbs.}$$

Or, taking 85 per cent. of the boiler pressure,

$$\frac{D^2 \times L \times .85\,(160)}{W} = 17{,}625 \text{ lbs.}$$

Fig. 19 shows graphically the reason it is not desirable to increase the mean tractive force above about 25 per cent. of the total weight, except, perhaps, in some exceptional cases, such as engines working exclusively on steep grades, where it is often necessary to start a heavy train with the cranks in any position, the most difficult being when one is on the dead center.

Fig. 20 is a card at 25 miles an hour, cut-off at one-half stroke, mean effective pressure 93 lbs. The tractive force of this card is plotted in fig. 21—maximum, 14,700; minimum, 10,500; mean, 11,926. Except in the position from 35° to 40° on the forward stroke, the tractive force is remarkably uniform, the fluctuations not exceeding 2,000 lbs. The speed at 35 miles per hour, given in fig. 23—cut-off, 8 in. (one-third stroke); mean effective pressure, 57.6 lbs. This diagram is corrected for the influence of reciprocating parts. The corresponding tractive force is given in fig. 23—maximum, 10,250 lbs.; minimum, 5,500 lbs.; mean, 7,350 lbs. The tractive force, based on the primary card, is shown on dotted lines, and the corrected card in full lines. These three cards, figs. 18, 20, 22, are based on actual indicator diagrams taken at the same speed. It will be interesting at this point to compare the last one with a corrected, made-up diagram, fig. 24, representing the maximum, mean, effective pressure considered

The great gain in this is at once apparent, although the limiting efficiency of a freight engine is usually by its failure to surmount some difficult place on the road, where the grade is a little steeper, longer, or the curves sharper than the normal conditions.

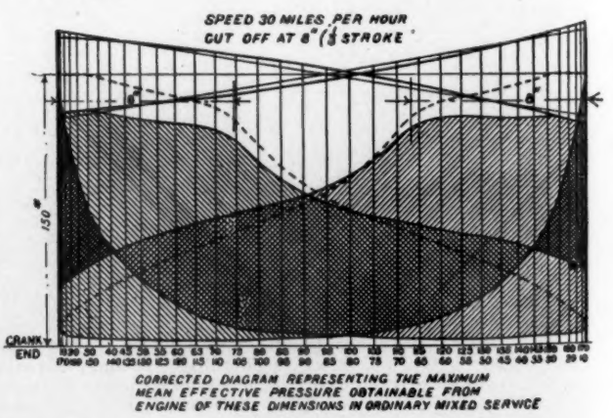

SPEED 30 MILES PER HOUR
CUT OFF AT 8" (⅓ STROKE
150
CRANK END
CORRECTED DIAGRAM REPRESENTING THE MAXIMUM MEAN EFFECTIVE PRESSURE OBTAINABLE FROM ENGINE OF THESE DIMENSIONS IN ORDINARY MIXED SERVICE

Fig. 24.

The speed would be much slower, no doubt, on these conditions. This, however, serves as an illustration of the improvement which can often be effected by the reduction of back pressure, higher initial pressure, etc.

Among the superior attributes of the future motive power—the electric locomotive—will, no doubt, be its uniform turning moment. The tractive force drawn in the same manner would be a straight horizontal line, which could be raised at

pleasure in parallel lines from zero to the maximum, allowing the total adhesion to be utilized.

Some interesting but impossible indicator diagrams can be made by reversing the process and drawing the line of tractive force straighter than it actually appears, filling in the low places and cutting down the high points in the attempt to make it more uniform. Such efforts, while they are instructive and useful at some speeds, must necessarily be extremely limited where most needed—that is, for cards taken at the start to 3 or 4 miles per hour.

The conclusions reached by the writer are: First, that the most profitable course to pursue to reduce the vertical effect of counterbalance is to lighten the reciprocating parts, considering carefully the strains to which they are subjected, and paring down the unnecessary weights to a minimum wherever possible; 25 per cent. can be removed without unduly weakening the parts, and in many cases a much greater improvement can be effected.

Second, for high-speed engines decrease the piston speed, and consequently the revolutions per minute, by increasing the diameter of the drivers; as the centrifugal force increases directly as the square of the number of revolutions per minute, the effect is very marked.

At 70 miles per hour the number of revolutions per minute, with 68 in. drivers, is 346, $346^2 = 119.716$
" 78 " " " 301, $301^2 = 90,601$

29,115,

the reduction in centrifugal force being 24.3 per cent., effecting at the same time a much better distribution of steam and greatly reducing the wear and tear of machinery.

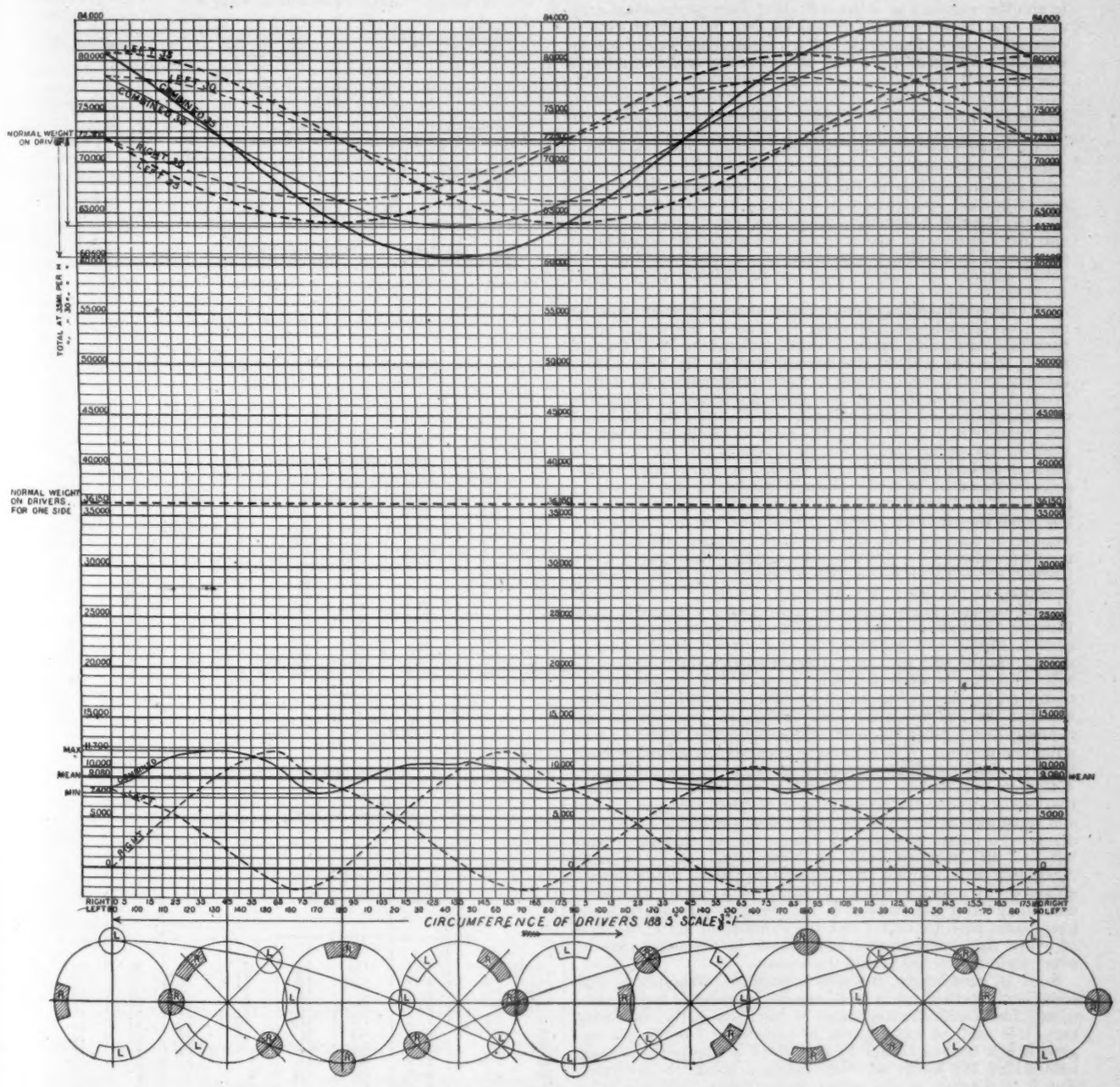


Fig. 25.

A NEW FOG-SIGNALING APPARATUS.

THOUGH the public, in the extraordinary change of climate which has come over England in the last 12 months, may have almost forgotten the meaning of the words "London fog," the matter is not likely to pass from the mind of the railway manager. Year by year as railway traffic gets denser and railway lines are more crowded, the delays and expense caused by a serious fog become more intolerable. Nor is this the only reason why the old-fashioned detonator fastened to the rail

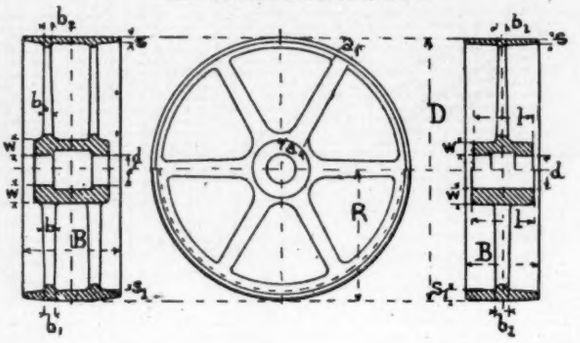
with a wire clip by human agency is constantly felt to be more inadequate for its purpose. A fog-man must not only be a trained railway man, but also must be familiar with the exact spot at which he is called to work. With the new ideas that have grown up on the subject of permissible length of hours of labor, the supply of such men is likely to fall short. The risk, moreover, of the occupation is inevitably great, and risks of this kind are less submissively borne than was the case a few years back. For all these reasons, a satisfactory mechanical system to replace manual labor entirely is likely to meet with a cordial welcome. Before, however, any system can be accepted as satisfactory, it will, undoubtedly, have to run the gauntlet of a great deal of keen professional criticism, and to survive the ordeal of long and severe tests in every-day use. Meanwhile, a very interesting and in several respects novel mechanism has been experimentally fitted up a few miles out of London on the new Tottenham & Forest-gate Line, where it has been examined with interest by a number of practical railway men. Seeing that patents for fog-signaling apparatus have fallen for years past almost as thick as the leaves in Vallombrosa, and that the bulk of them have been wholly unworkable in practice, whatever might be their theoretic advantages, it is well for the new apparatus that its patentees are not amateurs, but engineers by profession. They are Mr. George Abernethy, the son of the famous engineer, and Mr. Timmis, the maker of the first automatic signals ever introduced in England, which have now been working with entire success for months past on the Liverpool Overhead Railway.

In brief outline the system consists of a wire circuit passing down the signal-post and along the line to the signal-cabin, then back to a point opposite the signal, where it is attached to a contact-bar laid on the ground between the rails. With this bar connection is made as each train passes by a wire brush fixed on the front of the locomotive, and the circuit is completed by the current passing out through the wheels of the locomotive and so along the rails to the point of origin. Both on the engine and in the signal-cabin the current is led through an instrument, looking much like an ordinary block-signal instrument, with a polarized needle, so that as long as the circuit is open the needle hangs straight up and down; but when the circuit is closed by the brush on the locomotive coming in contact with the bar fixed between the rails, the needle is deflected to the one side, giving "line clear," if the position of the signal causes the current to flow in the positive direction, to the other side, showing "danger," if the signal arm is up and the current is accordingly a negative one. Further, the indicator on the engine is supplemented by an audible signal, and according as the current comes from a signal that is "off" or "on," it either rings a shrill chattering bell or strikes a deep-sounding gong. The engine-driver, therefore, has no need to watch his indicator, and might know whether the line was clear even though he were out on the running board with his head under the boiler while he was oiling the motion. If it is thought necessary, it would be easy to fit up similar audible signals in the signalman's cabin also. A further requirement is met by this new patent. Conflicts frequently arise on the occasion of an accident between drivers and signalmen as to who was responsible—whether it was the driver who passed a signal of danger, or the signalman who left it "off" when it ought to have been "on." Messrs. Abernethy and Timmis are prepared to attach to the signals an automatic recorder which, working with a train of wheels something after the fashion of an ordinary gas meter, shall keep count both for driver and for signalman, in the one case of every signal the engine has passed, in the other case of every train which has passed the signal.

Such is, very briefly, the new apparatus. Whether it will come into practical use it is, of course, impossible for any one to say, for though the apparatus is far from costly, requiring only, it is said, an expenditure of something like 50*s.* per engine, it is a serious matter to undertake a wholly new departure where the safety of the traveling public is involved. But it is possible at the outset to find more than one point which should be strongly in its favor. In the first place, it gives not merely a negative but a positive signal. The existing fog signals only tell a man now and then that he must stop instantaneously. The new system would tell him each time he passed a signal showing "line clear" that he might proceed with safety. And the difference may, at times, be of vital importance, for accidents have happened before now through drivers losing their bearings entirely, and suddenly finding themselves some miles further along the line than they had supposed. Then, again, the indicators, both in the signal-cabin and on the engine, being on the same circuit, it is impossible for them to tell two contradictory tales at the same moment. Not only does the driver know where the signal is, but the signalman knows it too, and the driver knows that the signalman knows it. With these great advantages in its favor at the outset, we shall probably hear more before long of Messrs. Abernethy and Timmis's fog-signaling patent.—*London Times.*

DIMENSIONS OF CAST-IRON PULLEYS (DOUBLE ARMS)

BREADTH FROM 11 IN. TO 14 IN.



D.	No. of Arms.	a	a_1	b	b_1	s	s_1
8 to 12	2×4	1¼	1	⅝	⅝	⅜	⅜
12½ " 15½	2×4	1⅜	1	⅝	⅝	⅜	⅜
16½ " 19½	2×4	1⅜	1	⅝	⅝	⅜	⅜
20 " 23½	2×6	1⅜	1	⅝	⅝	⅜	⅜
24 " 27½	2×6	1⅜	1	⅝	⅝	⅜	⅜
28 " 31½	2×6	1½	1⅛	⅝	⅝	⅜	⅜
32 " 35½	2×6	1⅝	1⅛	⅝	⅝	⅜	⅜
36 " 39½	2×6	1⅝	1⅛	⅝	⅝	⅜	⅜
40 " 43½	2×6	1⅝	1⅛	⅝	⅝	⅜	⅜
43½ " 47½	2×6	1⅝	1⅛	⅝	⅝	⅜	⅜
47½ " 51	2×6	1⅞	1⅛	⅝	⅝	⅜	⅜
51½ " 55	2×6	1⅞	1⅛	⅝	⅝	⅜	⅜
55½ " 61	2×6	2	1⅛	⅝	⅝	⅜	⅜
61½ " 67	2×6	2⅛	1⅛	⅝	⅝	⅜	⅜
67½ " 72½	2×6	2⅛	1⅛	⅝	⅝	⅜	⅜
67½ " 72½	2×8	1⅝	1⅛	⅝	⅝	⅜	⅜
72½ " 78½	2×6	2⅛	1⅛	⅝	⅝	⅜	⅜
72½ " 78½	2×8	2⅛	1⅛	⅝	⅝	⅜	⅜

$$W = \frac{d}{6} + \frac{D}{100} + \tfrac{3}{4} \text{ to } \frac{d}{6} + \frac{D}{100} + 1\tfrac{1}{2}$$

$r = 0.80\,a$ = radius of elliptical arm.

BREADTH FROM 14½ IN. TO 20 IN.

D.	No. of Arms.	a	a_1	b	b_1	s	s
8 to 12	2×4	1⅜	1⅛	⅝	⅝	⅜	⅜
12½ " 15½	2×4	1⅜	1⅛	⅝	⅝	⅜	⅜
16½ " 19½	2×4	1½	1⅛	⅝	⅝	⅜	⅜
20 " 23½	2×6	1½	1¼	⅝	⅝	⅜	⅜
24 " 27½	2×6	1⅝	1⅛	⅝	⅝	⅜	⅜
28 " 31½	2×6	1⅝	1⅛	⅝	⅝	⅜	⅜
32 " 35½	2×6	1¾	1⅛	⅝	⅝	⅜	⅜
36 " 39½	2×6	2	1⅛	⅝	1	⅜	⅜
40 " 43½	2×6	2⅛	1⅛	⅝	1	⅜	⅜
43½ " 47½	2×6	2⅛	1⅛	⅝	1⅛	⅜	⅜
47½ " 51	2×6	2⅛	1⅛	⅝	1⅛	⅜	⅜
51½ " 55	2×6	2⅛	1⅛	⅝	1⅛	⅜	1
55½ " 61	2×6	2⅛	1⅛	⅝	1⅛	⅜	1
61½ " 67	2×6	2⅛	1⅛	⅝	1⅛	⅜	1
67½ " 72½	2×6	2⅛	1⅛	⅝	1⅛	⅜	1⅛
67½ " 72½	2×8	2⅛	1⅛	⅝	1⅛	⅜	1⅛
72½ " 78½	2×6	2⅛	1⅛	⅝	1⅛	⅜	1⅛
72½ " 78½	2×8	2⅛	1⅛	⅝	1⅛	⅜	1⅛

$$W = \frac{d}{6} + \frac{D}{100} + \tfrac{3}{4} \text{ to } \frac{d}{6} + \frac{D}{100} + 1\tfrac{1}{2}$$

$r = 0.80\,a$ = radius of elliptical arm.

—*Mechanical World.*

THE VIBRATIONS OF STEAMERS.

Further Investigations of the Vibrations of Steamers.*

By Herr Otto Schlick.

The paper which I had the honor to lay before you at the last year's meeting of the Institution of Naval Architects appears to have been sufficiently interesting to the members to encourage me to communicate to you now the results of my further investigations on the same subject.

It is no doubt very desirable to have a reliable formula for determining with some degree of accuracy the number of revolutions which the engines of a steamer should make in order to avoid altogether, or at least reduce to a minimum, the violence of the vibration inherent in ships themselves, and in the distribution of the weights in them. Such a formula I had already worked out some time ago, but before publishing it I took care to test and correct the coefficients occurring in the formula, by applying it to a number of steamers already doing service.

This was not an easy task for me, as I had not the opportunity of ascertaining, with accuracy, the critical number of revolutions of the engines above referred to, excepting in the case of a very limited number of steamers in the merchant service. Many vessels vibrate violently when running under steam, but in most cases the revolutions of the engines cannot be increased to the number necessary to bring about a decrease of the vibrations; so that this critical number of revolutions can ordinarily not be ascertained.

The mathematical formula for the period of vibration of an elastic rod or girder is very complicated, but in the case of a ship's hull its compilation is comparatively simple. Let an imaginary weightless elastic rod be firmly secured at one end, while at the other end let the mass M be attached and the force Q applied. The latter will bend the rod and move the mass M through a distance λ from its original position, to which M will return with a certain acceleration, when the force Q is withdrawn.

If the acceleration at the distance 1 from the horizontal position of the rod is called q, then the time of oscillation of the rod will be found by the well-known formula

$$t = \frac{W}{\sqrt{q}}.$$

If, now, the force K is applied to the free end of the rod, and the distance through which M is moved downward by this force is equal to χ, then

$$\frac{K}{Q} = \frac{\chi}{\lambda},$$

that is, the distance through which the free end of the rod is moved by the bending forces are proportional to these forces.

If the acceleration given to M by the bending force K at a distance χ is called p, then

$$p = \frac{K}{M} = \frac{Q}{M\lambda} \cdot \chi.$$

If χ is put equal to 1, then will be,

$$q = \frac{Q}{M\lambda},$$

λ signifying the distance through which the rod is bent by the force Q, and $\frac{\lambda}{Q}$ being a constant quantity, λ_1 may be put for λ in the case of the bending of the rod having been caused by the weight of the mass M alone. We can, therefore, put

$$Q = Mg,$$

g signifying the acceleration of gravity. Therefore the time of oscillation is

$$t = W\sqrt{\frac{\lambda}{g}}. \qquad (1)$$

The distance χ through which an elastic prismatic rod is bent by the force K, the weight of the rod being neglected, may be found by means of the formula,

$$\chi = \frac{K \cdot l^3}{3 \cdot E \cdot T}, \qquad (2)$$

l signifying the length of the rod, E the modulus of elasticity of the material, T the moment of inertia of the section of the rod.

If, now, in the formula (1), instead of λ_1, the value of χ from the formula (2) is put, we have

$$t = W\sqrt{\frac{K l^3}{3 \cdot E \cdot T \cdot g}}. \qquad (3)$$

The direct application of this formula for calculating the time of oscillation in the case of a ship's hull is, however, only admissible on the supposition that the weight of the ship is concentrated in one point. Therefore $\frac{L}{2}$, half the length of the ship, must not be put at once instead of l in formula (3). It is, however, admissible to suppose that the weight of half the ship, the same being divided by the midship section into two equal parts lengthways, is concentrated in one point at a certain distance from the midship section, and that the time of oscillation in this imaginary case be the same as in that of a real ship, in which the weights are distributed in the usual way along the whole length.

This imaginary distance may be expressed by $a \times \frac{L}{2}$ (a being smaller than 1), but need not be taken into consideration at present.

Upon this supposition the formula (3) may be used at once to determine the time of oscillation for a ship.

If D signifies the displacement (weight) of a ship, then is the time of oscillation expressed by the formula

$$t = W\sqrt{\frac{\frac{D}{2} \cdot \left(a\frac{L}{2}\right)^3}{3 \cdot E \cdot T \cdot g}}.$$

The joint value of all the factors in this formula being put equal to ξ, we have

$$t = \xi\sqrt{\frac{D \cdot L^3}{T}}.$$

From which follows, if the number of vibrations of a certain type of ship per minute be

$$N = \frac{60}{t},$$

$$N = \phi\sqrt{\frac{T}{D \cdot L^3}}.$$

If in this formula D is expressed in English tons, L in English feet, and, for the calculation of the moment of inertia, the sectional areas in English square inches, and the distances of the centers of gravity from the neutral axis in English feet, then the coefficient will be, for

Vessels with very fine lines, such as torpedo-boat destroyers	$\phi = 156850$
Large transatlantic passenger steamers with fine lines	$\phi = 143500$
Cargo boats, with full lines	$\phi = 127900$

This formula gives generally reliable values, and even alterations in the distribution of weights do not materially influence the result.

In order to adjust the coefficients to exceptional cases, it is only necessary to bear in mind that a removal of the weights from the ends and the middle of a ship—viz., an accumulation of the weights near the nodular points of vibration, will increase the number of vibrations, and, *vice versa*, that this number will decrease when the weights are accumulated near the ends and the middle of a ship.

It would, of course, be more correct to consider in the formula the distribution of the weights in the longitudinal axis of the hull; but as this would require a very tedious calculation, which would, moreover, not always be reliable, and as I consider it particularly important to construct a formula which easily adapts itself to practical use, I have thought it better to employ only the coefficient ϕ, which I ascertained

* Paper read before the Institution of Naval Architects.

from results obtained with reference to existing ships. After more experience has been gained, it will be possible to find perhaps more correct coefficients for the ordinary types of steamers in which the distribution of the weight is analogous.

In order to avoid vibration with perfect certainty, the normal number of revolutions must, as is known from experience, be at least from 10 to 12 per cent. less, or else considerably greater than the number of vibrations. In case the number of revolutions should be only inconsiderably greater, there could arise the possibility that even a small diminution of the steam pressure, hardly always to be avoided in practice, would immediately cause vibrations of great violence.

A ship's vibrations have until now never been closely examined with regard to the influence exercised by the position of the engines in the ship, and I myself touched this subject only

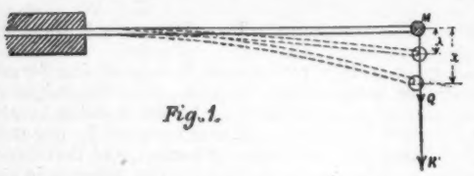


Fig. 1.

superficially in my previous publications. Although it is comparatively easy to find out the consequences of shifting the engines in a ship by argument, yet the attempt to prove the conclusions arrived at by practical tests on a steamer will remain very costly and difficult. I therefore had recourse to a model to show the results caused by shifting the engines of a ship in a fore-and-aft direction.

This model, represented by figs. 2 and 3, consists principally of a plank, *P P*, about 8 ft. long and 11 in. broad, suspended horizontally by 10 helical springs, *S S*, arranged in two rows lengthways near the edges of the plank. These helical springs are attached to a frame, *F F*, the construction of which is immaterial.

Along each edge of the plank *P P* are also arranged in two rows a number of weights, *W W*, which can be easily shifted.

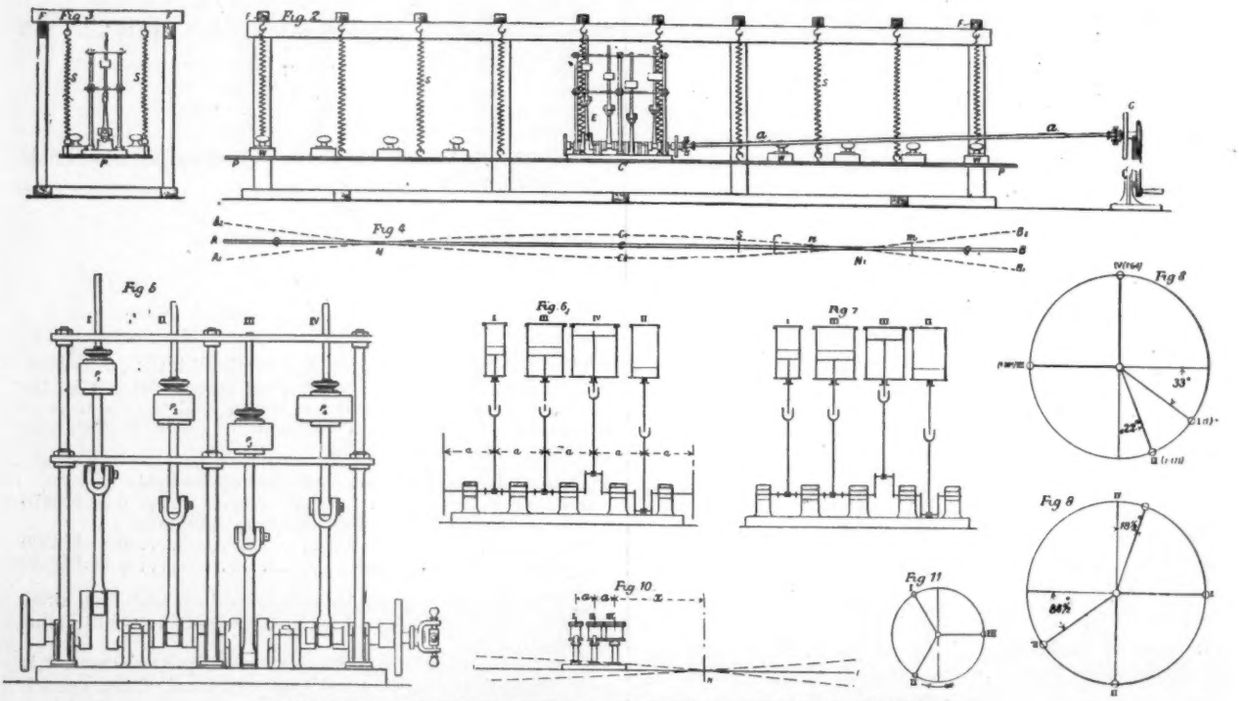
The plank suspended, as above described, can thus easily be made to vibrate in the manner shown at fig. 4, by a regularly repeated impulse of the hand, either at the middle or at the ends. These vibrations will be called in future vibrations of the I. order, in distinction from vibrations of another kind. Every one who has been on board a violently vibrating steamer will acknowledge at once the perfect analogy of the vibrations of the plank with those of a steamer.

A model engine, as shown at fig. 5, serves for further investigations. The shaft has four cranks, which can be easily adjusted at any angle with each other by a screw arrangement. The pistons are represented by four different weights p_1, p_2, p_3, p_4, which can be easily removed and exchanged for others, to show the effect produced by the use of pistons of different weights. This model engine is placed, as shown at fig. 2, on the plank *P P*, and made to revolve by the turning gear *G* in connection with the spindle *a a*, which is furnished at each end with a universal joint and also with a telescopic sliding arrangement, so that the engine *E* can work perfectly freely.

Another model engine of similar construction, but with three cranks, is used to explain the influence of ordinary triple-expansion engines on the vibration of steamers.

In the first place, let the pistons, piston-rods, and connecting-rods of two cranks of the three-crank engine be removed, so that the model may represent a tandem engine—viz., an engine with only one crank. When the apparatus in this state is set in motion, only forces acting alternately up and downward in a vertical direction will come into action, without any rocking couples being formed in the vertical plane through the longitudinal axis of the ship.

If the model engine be placed at *C*, the middle of the plank representing the ship (see fig. 4), and made to work first slowly and then gradually faster, it will be observed that the plank will remain at rest until the revolutions have reached a certain number, when violent vibrations of the form A_1 C_1 B_1 and A_2 C_2 B_2 (see fig. 4) will make themselves manifest. The violence of these vibrations will, however, decrease again to perfect rest when the number of revolutions of the engine is gradually increased. Exactly the same will be observed when the model engine is shifted to *O* or *Q* near the end of the plank.



APPARATUS FOR EXPERIMENTING ON THE VIBRATIONS OF STEAMERS.

This plank represents a ship's hull, and by means of it the origin of vibrations in a ship may be demonstrated, by applying to it forces, in a similar way as they would occur in reality in a ship. If, for instance, at one part of the plank a pressure is exercised, the plank will give way in the direction of that pressure either up or downward, until through the increased tension of the respective springs equilibrium is re-established, similar to the action of increased buoyancy in the case of a ship.

When, however, the engine is placed exactly over one of the nodular points *N* or N_1, then the plank will remain at rest, or nearly so, at any number of revolutions that the engine may be worked at. The vibrations, as shown at fig 4, will be replaced by others of a higher order, having more than two nodular points, depending on the number of revolutions the engine is worked at.

These facts are, however, of little use in practice, as it is impossible to determine with accuracy the position of the

nodular points for a ship in course of construction; moreover, that position is not constant, but varies with the distribution of the weights in the ship.

For further investigations, the cranks belonging to the cylinders I. and IV. of the model engine, shown at fig. 5, are placed exactly opposite to each other—viz., at an angle of 180°. The weights of the two respective pistons p_1 and p_4 are made exactly equal, and the two connecting-rods and piston-rods of the cylinders II. and III. are removed altogether. With such an engine with two cylinders the algebraical sum of the forces will always be zero—viz., they will be perfectly balanced in a vertical direction at any position. During the first half of a revolution a couple will be created, having the tendency to lift the engine-bed abaft, and during the second half a couple with the exactly opposite tendency.

When such an engine is placed exactly in the middle of the ship, vibrations of the I. order, as shown at fig. 4, cannot be produced, but the ship will remain at rest. Only small vibrations will occur when the engine is placed near the end of the plank, considerably abaft the nodular point. Both assertions can be proved by experiments with the model.

When, however, this engine is placed with its two cylinders equidistant from the nodular point (that means when one cylinder is placed at the same distance after the nodular point as the other one is placed before it), very violent vibrations of the I. order will be produced as soon as the revolutions of the engine have reached the critical number. This can easily be gathered from fig. 4, considering that during the first half of a revolution a downward force at n, and an upward pressure at m, will take place simultaneously, and that these pressures will be reversed during the second half of the revolution. Vibrations will also be produced when the engine is placed with its cylinders not equidistant from the nodular point.

If, for an instance, one of the cylinders is placed exactly over the nodular point N_1, fig. 4, and the other toward the middle of the ship over r, the thrusts of the piston acting exactly over the nodular point will have no effect in producing vibrations, while the thrusts of the other piston acting at a distance from the nodular point will cause violent vibrations.

In shifting the engine gradually toward the middle of the ship, the vibrations will decrease in the same measure until they entirely disappear as soon as the engine has reached the middle position.

The following rules, based on the above-described experiments and observations, may be laid down for the construction of a ship's engines, so as to avoid vibrations:

1. In the case of engines that are placed exactly at the middle of the ship or near its ends, the algebraical sum of the vertical forces generated by the reciprocating masses must be made equal to zero. Rocking couples, which may possibly arise, need not be taken into consideration, as their influence in producing vibrations is but small.

2. In the case of engines that are placed over or near one of the nodular points, rocking couples acting in the vertical plane through the longitudinal axis of the ship must be avoided, in order to do away with vibrations. It is, however, less important that the algebraical sum of the vertical forces be equal to zero.

The second case only will come into consideration in practice, as it is impossible, under ordinary circumstances, to place the engine in the middle of the ship. On the contrary, it will be requisite for the proper arrangement of the boilers to place the engine considerably abaft, near to the nodular point

In designing the engine special care must, therefore, be taken to avoid rocking couples.

The usual arrangement of a three-cylinder engine is that the high-pressure cylinder is placed foremost, the middle-pressure cylinder in the middle, and the low-pressure cylinder at the after end.

Considerable rocking couples will always be produced with such an arrangement, and, moreover, the alternately upward and downward forces at the after end of the engine-bed will be greatly in excess of similar forces at the fore end, because the weight of the low-pressure piston is naturally greater than that of the high-pressure piston. An ordinary triple-expansion engine may, therefore, be used when it is placed before the nodular point in question, because then the greater pressures are applied nearer to that point than the smaller, and the engine will therefore work better.

But when the engine is placed abaft the nodular point, as is generally the case with tank steamers, then the greater force will act also at a greater distance from the nodular point, and cause, therefore, more violent vibrations. The usual position now given to triple-expansion engines in tank steamers is, therefore, as regards producing vibrations, the most unfavorable. The low-pressure cylinder of the engine should be placed foremost, and the high-pressure cylinder abaft.

Moreover, the rocking couples, inherent in a triple-expansion engine, would be considerably reduced if the low-pressure cylinder were arranged between the high and middle-pressure cylinders, because then the greatest pressures produced by the reciprocating masses would act nearly in the center of gravity of the engine. With such an arrangement not only the violence of the vibrations would be reduced, but also the strain on the engine-bed, which often causes loosening of the fastenings.

It is, therefore, to be recommended for any engine of the three-cylinder type, the low-pressure cylinder should be placed in the middle between the two other cylinders. In the case of an engine with five cylinders and three cranks—viz., one cylinder for the middle crank, and a pair of cylinders for each of the outer cranks, very great rocking couples are produced, as the piston weights for each pair of the outer cylinders are considerably greater than that of the middle cylinder. These engines will, therefore, cause especially violent vibrations.

An ordinary triple-expansion engine with three cranks, if erected in a particular manner, would also not be able to put the body of the ship into a state of violent vibration. To make this clear, refer to figs. 10 and 11. Let the line $A\ B$ represent the axis of the ship; let N be the aftermost nodular point; let B be the stern, and A about the middle of the ship. Let it be also assumed that the engine, as is usually the case, is placed somewhat in advance of the nodular point. When the revolution of the engine takes place in the direction indicated by the arrow in fig. 11, and the cranks occupy, for example, the position shown, the weight of the piston of cylinder No. III. will generate a considerable upward force, while the pistons of cylinders Nos. I. and II. generate forces in the opposite direction. If, now, the distance x of the engine from the nodular point N be such that the moments of these forces about the nodular point N be equal to zero, no vibrations of the first order can take place.

As, however, the weights of the moving parts of the separate cylinders of an ordinary triple-expansion engine generally stand to each other in the ratios of 1 : 0.82 : 0.73, we have, in order that no vibrations may take place, the simple calculation that the distance x of the low-pressure cylinder must be about five times a, the distance apart of the cylinders from center to center. It results, also, that for every type of engine there is a position in the ship where the engine may be erected which renders it possible to avoid vibrations.

By proper balancing rocking couples, as well as vertical forces, vibrations may be avoided altogether. The use of counterweights is, however, not expedient, when the same have to be too heavy, and is almost inadmissible for very large engines. For instance, for a triple-expansion engine of 7,000 indicated H.P., the counterweights required would amount to 44 tons, if the stroke of the eccentrics for moving these weights be 20 in. at one end and 12 in. at the other end of the engine. It is, therefore, by all means necessary to reduce the counterweights to a minimum, or, better still, to do away with them altogether. This may be carried out partially by giving the engine a proper construction or position in the ship.

With this object in view, the weights of the three pistons for a three-cylinder engine have been made exactly equal. With such a construction the algebraical sum of the vertical forces is equal to zero for any position of the cranks; and if such an engine be placed exactly in the middle of the ship, no vibrations could be produced, as has been demonstrated before. But as soon as such an engine is placed near one of the nodular points, which is nearly always the case, violent vibrations will be caused by the rocking couples inherent in the construction of the engine.

These couples are even greater than those inherent in an ordinary triple-expansion engine, because the small weight of the high-pressure piston at the fore end of the engine is replaced by the much greater weight of the low-pressure cylinder. However, these difficulties may be overcome entirely, or at least greatly reduced, by adopting engines with four cylinders and four cranks. Two methods of construction, which differ chiefly in the relative position of the cranks to each other, come here into consideration. In one of these methods the cranks are so arranged that in each pair at each end of the engine they form an angle of 180°—viz., stand exactly opposite each other, while the two pairs themselves stand at an angle of 90°. The two small cylinders are placed at the ends, and the two large cylinders between them in the middle of the engine.

The construction of such a quadruple-expansion engine is represented in sketch at fig. 6. The steam enters at cylinder I., and passes through the cylinders II., III. and IV. successively. The cranks of the successive cylinders stand, therefore, always at an angle of 90° to each other. The steam

might also be made to take a different course through the respective cylinders; but care should always be taken that the two heaviest cylinders, or the heaviest piston weights, are placed in the middle—viz., between the two lighter cylinders.

Fig. 7 represents the arrangement of a triple-expansion engine of this system with two low-pressure cylinders. The advantages of this construction are, first, that the forces produced by the reciprocating masses of any two adjoining cylinders are nearly balanced—viz., that the algebraical sum of the existing vertical forces is approximately equal to zero; and, secondly, that only very small rocking couples can be produced. In most cases counterweights may be either entirely dispensed with, or will only require to be of such a size that there will be no difficulty in their adoption.

In case the engine is placed very near the nodular point, it is very desirable to balance the couples that might be formed. As the balance-weights need not be very large, it is admissible to let them rotate, without any fear of injurious horizontal components being produced. The simplest way of balancing the respective forces is to fit a balance-weight on the periphery of the wheel of the turning gear, with which every engine is furnished; and also a disk of suitable diameter on the fore end of the crank-shaft. This disk, which also bears a balance-weight on its periphery, can always be easily fitted and offers no danger to the engine-room staff.

In order to reduce the counterweights for these disks to a minimum, the weights which work at the two outside cranks of the cylinders I. and II., fig. 6, must be smaller in a certain ratio than those working at the two inside cranks of the cylinders III. and IV. The determination of the exact ratio of these weights to each other mathematically is rather complicated, but supposing that the weights which act on the crank II. are in the same proportion to those which act on the crank IV., as the weights which act on the crank I. are to those which act on the crank III., and further supposing, for the sake of simplicity, that the counterweights are arranged at the same distance (*a*) from the center lines of the outside cylinders as these cylinders are distant from each other, then the weights of the moving parts of the outside cylinders must be 0.823 times the corresponding weights of the adjoining inside cylinder.

If the counterweights for a four-cylinder engine of this construction of 7,000 indicated H.P. are calculated according to this rule, the respective weights will be 2.68 tons and 2.45 tons. It is, however, here supposed that these counterweights are fitted at a distance from the center of the crank-shaft equal to the radius of the crank. Although these weights are considerable, yet they might be applied to an engine of the above size without hesitation.

In the case of an engine with four cranks, the counterweights might, however, be avoided altogether, and all possible existing forces and rocking couples be balanced, if it be not made a condition that all the four cranks are placed at an angle of 90°. This arrangement will suffice for all requirements of a completely balanced engine. The masses acting on the outer cranks form, so to speak, the counterweights for the forces acting on the inner cranks. If, therefore, the weights of the pistons for the outer cylinders are chosen rightly, and their respective cranks are put at the proper angles, such an engine will always work without producing vibrations in the ship. The position of the four cranks to each other might vary considerably. For instance, the position of the two inner cranks may be chosen optionally, and the weights of the pistons of the outer cylinders, as well as the position of their respective cranks, be arranged accordingly.

The two inner cylinders must, in this arrangement, be furnished with the heaviest pistons, and it will, therefore, be best, also, to place the largest cylinders in the middle If the cranks for the two cylinders III. and IV., fig. 6, are placed at an angle of 90° to each other, the arrangement shown at fig. 8 might be adopted for the cranks. The relations of the moving weights for each cylinder are marked at each crank in brackets, as shown.

The movement of the forces acting on the crank-shaft during one revolution will, in this arrangement, vary more than would be the case if all the cranks were placed at an angle of exactly 90° to each other. These circumstances are, however, not so unfavorable as might at first appear, and differ but little from those of three cylinder engines, if the cylinders have only the proper diameters. The cranks belonging to the cylinders I. and II. might also be placed at an angle of 90° to each other. The arrangement of the remaining cranks consequently required will be seen in fig. 9.

Any number of arrangements similar to those represented at figs. 8 and 9 might be made and used in practice. It will be easily seen that, if the angle at which the cranks of the cylinders I. and II. are placed to each other is made smaller, the angle for the cranks of the two other cylinders will also have to be smaller.

In the case of a triple-expansion engine with four cylinders, as shown at fig. 7, the relative positions of the cranks to each other will be symmetrical, and therefore the motion of the engine will be still more even. This principle may also be applied to engines with three cranks only, when the moving parts of an imaginary fourth cylinder are replaced by a counterweight at the after end of the engine. This counterweight may, as already proposed for four cylinder engines, be attached to the wheel of the turning gear. By using such a counterweight and adopting the proper angles for the cranks, the vibrations of already existing steamers can be greatly reduced, or even entirely obviated.

From the foregoing observations it will be easily seen that in designing a ship it is of the greatest importance to determine, in the first place, the position of the nodular points.

If the weights of a ship were distributed equally in the direction of the longitudinal axis, and the moment of inertia of any cross-section at any distance from their common axis were always the same, then the position of the nodular points would be 0.2242 times the ship's length distant from its ends.

This value is, however, greatly influenced by the more or less equal distribution of the weights, and I may, perhaps, have the honor to lay before you the results of my experiments and observations on this head on a future occasion.

TRIALS OF H. M. S. "HORNET."

A NOTEWORTHY series of trials of the new torpedo boat destroyer the *Hornet*, built and engined by Messrs. Yarrow & Co., of Poplar, were brought to a highly satisfactory conclusion recently by the completion of the official trials of the vessel, which took place off the mouth of the Thames.

There was recorded in the *Times* of November 22 ult., under the heading of "Water-Tube Boilers in the Navy," the experimental trial of a new boiler on the water-tube principle patented by the builders of the *Hornet*. The boiler, as stated, was one of eight with which the *Hornet* was to be fitted, and from the tests to which it was then subjected it gave evidence of capabilities as a steam generator for sea-going purposes which have been practically realized within the past month. The trials of this new type of vessel have been in each case attended by Admiralty officials.

Preceding the final official trial of the vessel, a first private preliminary one was made on January 31 ult., which was a great success, as she then proceeded to sea with only four boilers on board, being half the boiler power, in a comparatively light condition, when a speed of 23.3 knots was realized, the boilers working at a very moderate air pressure, and supplying with ease all the demands made upon them for steam. On February 23, the whole of the eight boilers having been fitted on board in the mean time and the vessel completed, she proceeded on a trial which, in its results, is memorable, marking, as it does, the realization at sea of the highest steaming speed yet attained by any vessel, as she in three out of seven runs on the Maplin mile made over 30 knots, the average speed for the seven runs being 28 knots, the engines at the time making nearly 400 revolutions a minute, steam being maintained in the boilers at 172 lbs. pressure a square inch, with a little over an inch of air pressure. On March 7 a further trial was made with the vessel over the same ground with very fair success, the engines developing a total indicated power of about 4,000 horses, with 1¼ in. of air pressure in the stokeholds; but one of the guide-bars of the engines having begun to heat, it was deemed advisable to return and proceed with the vessel at a moderate speed to her moorings. On this occasion the vessel was rather deeper in the water than her normal loaded displacement.

Matters having been adjusted by the docking of the vessel, her manganese propellers fitted, trim regulated, and engines in sea-going order, she left Gravesend on Monday last and proceeded down the river. On reaching Thames Haven, about 10 A.M., a three hours' continuous trial was begun under forced draft, during which six runs on the Maplin mile were made, with the following results in speed attained:

Runs.	1	2	3	4	5	6
	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
Time	2 17.6	2 6.4	2 16.6	2 6.8	2 8	2 7.8
Speed in knots.....	26.16	28.48	26.35	28.39	26.03	28.16

Thus a mean speed was attained of 27.313 knots. On the completion of the mile runs, the vessel, for the remainder of

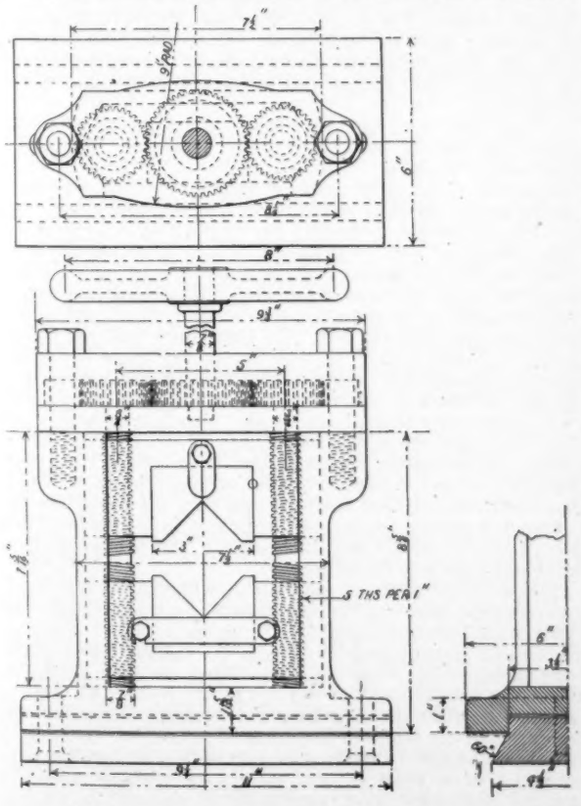
the trial time, was run straight out into the North Sea, and on the expiration of the three hours was found to have realized a mean speed over the whole of the time of 27.628 knots, the engines having run at a mean of 388.3 revolutions per minute and developed a total of 4,000 indicated H.P., with steam at a pressure of 169 lbs. per square inch and 1¼ in. of air pressure.

The *Hornet* is 180 ft. long and 18 ft. 6 in. beam, and at a mean draft of 5 ft. has about 220 tons displacement. Her propelling engines are twin triple compounds of Messrs. Yarrow's ordinary design for torpedo boats. The cylinders are 18 in., 26 in. and 39½ in. in diameter respectively, the piston stroke being 18 in. Her boilers are eight in number, having a total heating surface of 8,216 sq. ft. and a grate surface of 164.8 sq. ft., the furnace-bar length being 6 ft. 6 in. They are arranged in two stokeholds in groups of four, each pair of boilers having a funnel, thus giving four funnels to the vessel —the first ever fitted with so many in the British Navy—which with the exception of cowls for carrying air into the fans—horizontal ones in the case of the *Hornet*—and for other ventilating purposes are the only important projections above deck aft of the forward turtle back.

The main features of the Yarrow water-tube boiler having been popularly described in the issue of the *Times* before referred to, we have, in conclusion, to direct attention to what appears to be the very great advantage offered by the water-tube boiler of the Yarrow type over those wherein bent or curved tubes are adopted; as it is a matter of common knowledge that impurities in the feed water of a boiler are far more likely to adhere to the inside surface of a tube that is tortuous than of one in which the water of evaporation has a straight unchecked course in its circulation through the tubes as in the Yarrow boiler.—*London Times.*

PIPE CHUCK FOR LATHE.

We illustrate a pipe chuck which has been designed and is in use at the shops of the Philadelphia & Reading Railroad, at Reading, Pa., with a 16-in. Bement lathe. It is very frequently necessary to hold a pipe in order to cut the thread



PIPE CHUCK FOR LATHE, PHILADELPHIA & READING RAILROAD.

in the lathe, and for this purpose it is necessary that the chucking should be central with the spindle. The chuck which is illustrated is arranged so that the center line of the screws which draw the jaws together is exactly in line with the spindle of the lathe when set on the carriage, or, of course, if it were to be used with a larger lathe blocking up would be required, and with a smaller lathe it would probably have to be set upon the ways. The construction is clearly shown from the engravings. There is a hand-wheel over the center carrying a spur gear which meshes in with two others that are keyed to the stems of screws that are ¾ in. in diameter at the bottom of the thread, ⅞ in. outside the thread. These threads are rights and lefts, the rights being at the upper end, so that the jaws are moved together and grasp the pipe. The jaws are removable, and are held in position by the latches, which are shown on the front face of the side elevation, so that pipes of varying sizes can be held. As the two screws draw together quite evenly, there is no vertical thrust in either direction and no wear in this respect. The gears are housed in beneath a cap, which holds them down in position and at the same time excludes all dust and dirt. The device is a simple one, and will undoubtedly be suggestive to others from which they can arrange a similar device for lathes of their own when the necessity may arise.

PRESSED STEEL UNDERFRAMES.

The Leeds Forge Company have recently added to their establishment a large and important department. It consists principally of a large building 12,000 sq. yds. in area, of substantial construction, and already fitted with a good deal of costly plant, for the most part designed especially for the work in view. This work is the stamping out of the various members which go to make underframes, bogies, etc., for rolling stock. We believe that the idea of reducing the weight of rolling stock on railways was first impressed on Mr. Fox, who has worked out the details of the system, by seeing a heavy man on a light bicycle. He argued that if a vehicle weighing perhaps no more than 33 lbs. would carry a man weighing 200 lbs. on the high road, railway trucks and carriages could be constructed with a somewhat closer approximation of the ratio of weight of load to that of the vehicle carrying it. In the case of the bicycle the ratio is, as will be seen, as 8 to 1; the weight of an ordinary railway truck designed to carry 8 tons is about 5 tons, 18 cwt., which gives a ratio of 1½ to 1. No doubt Mr. Fox recognized that the conditions applying to a bicycle carrying a man and those of a railway truck carrying its load are vastly different. However this may be, Mr. Fox considered there was a large margin within which he could work, and the results, as he has brought them out in tangible form, seem fully to confirm his conclusions. It may be interesting here to give some figures from estimates which have been formed as to the world's consumption in railway underframes. In England there are (or were at the time the estimate was made) 20,000 miles of railway, and the published statements give 548,000 underframes, or about 27 to the mile. Taking the whole railway mileage open at the time for the whole world, excepting England, so far as obtainable from published statistics (principally "Bradshaw's Railway Manual"), and taking the number of underframes of rolling stock at only 10 to the mile, and adding the sum so obtained to the known number of underframes on English railways, we get a total of 3,150,000. We assume the death-rate at 5 per cent.; there would be 157,500 new underframes required each year, or over one every 10 minutes. The plan upon which the new works have been laid out is to produce one underframe every 10 minutes.

It has no doubt often puzzled engineers unconnected with railway matters—for instance, the designers of steel torpedo boats, how it is that wood has managed to hold its own for so long in the construction of underframes. There are, however, virtues in wood which do not appear on the surface, and difficulties in the way of application of iron and steel on a wholesale scale. Mr. Fox, having taken the bicycle as his prototype, naturally elected to stand or fall by steel. He came to the conclusion that where members had to be joined they must be riveted together by means of a flange stamped in one with the solid metal, and that the use of angle irons riveted on must be abandoned. It may be said generally, therefore, that Fox's system consists mainly of flanging steel plates into various forms. The most usual required for underframes is that of a plain channel section with ends, or, in other words, a trough form; so that while in cross section the form differs little from that of an ordinary rolled channel bar, the blank is solid, flanged all round, both at the sides and ends. In this way, when two bars are joined together, nothing further is required for attachment but the necessary bolts or rivets; the latter being preferable, as nuts are liable to shake loose. The abandonment of angle irons as a means of attachment enables a considerable saving to be made in weight, and greatly reduces the number of separate pieces. It will be evident that it is by no means necessary that all joints should be made at right angles; when required, they can be made at various degrees of inclination.

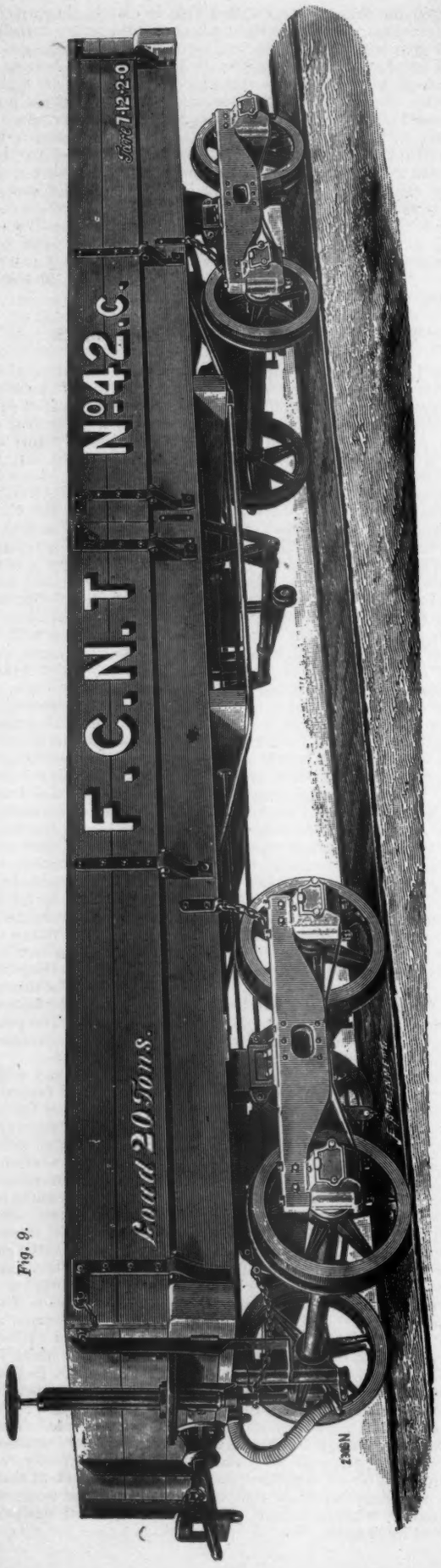


Fig. 9.

PRESSED STEEL IRON CAR, MADE BY THE LEEDS FORGE COMPANY.

Where pieces which may be called angles, or which correspond to angles, can be used with advantage in building up the patent underframes, they are of large size, and may be formed out of plates only ¼ in. thick. In this way a saving is made of 50 per cent. of weight over that required for similar angles or knees formed in the usual way; at the same time there is no loss of strength. The system of pressing thin plates also adapts itself very readily to the combination of separate parts; thus, a wagon or carriage headstock may be made which can be riveted in the flanges of every other piece abutting upon it; in this way there is no occasion for the numerous angle irons, gussets and knees used in the more ordinary forms of construction. With respect to the strength of frames produced, it may here be stated that a small bogie frame, weighing 728 lbs., was recently tested, and stood a load of 24 tons without deflection; it was not until the load was increased to a total of 55 tons, 10 cwt., 2 qr. that deformation took place. The flanges then were bent or deformed, but there was neither crack nor flaw in the metal, nor did the riveting give way, and the parts could with ease and trifling expense be restored to their original form. This test was made by dead weight piled on the bogie. Another test of a similar nature was made, in which a pair of American bogies, each weighing 812 lbs., had a dead weight test-load on the centerbar of both bogies of 130,186 lbs. There was no deflection or deformation of any kind, the test gauges pointing to zero. The bolster springs were pressed close, metal to metal.

This system of building up frames admits of duplication of parts being carried to great perfection. A design being once decided upon, the manner in which the various parts are molded insures exact similitude, and the necessary holes are spaced with precision by means of templates. The manufacturers claim that frames can be built up to given dimensions with the utmost nicety, the various parts square and true with each other, and the dimensions over all as exact as if the pieces had been planed to size. The result is a structure which cannot be destroyed unless by violent collision or similar accident. In ordinary cases, however, if a bar become bent it may be put right by an ordinary smith; but, supposing a piece is bent out of shape so badly as to become useless, the makers undertake to supply a duplicate that will fit properly if the other parts are uninjured. From the character of the material, fractures are extremely unlikely to be produced even by collision, as the flanges can be beaten down close without cracking.

Those who have had experience of the pressing of metal sheets into hollow forms will easily understand that it is no easy matter to obtain parts such as those shown in our illustration with a gauge of metal uniform throughout. To stamp single trough sections would be a comparatively easy matter, but this would necessitate the riveting on of angle attachment pieces, a mode of procedure which is diametrically opposed to Fox's system, and the avoidance of which constitutes the great merit of his plan. The rectangular trough, therefore, has to be provided with ends stamped out solid at one operation with the rest. To encompass this, the die and mold, or "the tools," as they are called, have to be very nicely proportioned. Great exactitude, which can only be attained by much experience, has to be observed in the formation of the upper edge of the mold. This has to be of a contour which will cause the proper flow of metal to the part required. It is further necessary that the edges of the trough, which is to form a member of the carriage frame, should be fair and even, without one part standing up above another, otherwise a certain amount of machining, in the shape of sawing off or otherwise, would be necessary, and this would naturally add greatly to the expense.

The strips of steel, bar and plate, which form the blanks from which the troughs are pressed, contain exactly the amount of metal required for the finished piece. They are placed in a furnace and brought to the required temperature for pressing—viz., a fair red heat. They are then placed flat upon the female mold in the hydraulic press, the table of which rises until the dies have duly entered the mold, thus forcing the flat plate into the required shape. If one were to attempt to perform such an operation as this, say, with a piece of paper or a sheet of cold metal, the surfaces would be doubled over each other, supposing, of course, the material were sufficiently tough for rupture not to take place. In the present case, however, were there any doubling over of the metal, there would be obviously a weak place; but doubling over is absolutely prevented, for the clearance or space between the die and mold is exactly the same as the thickness of the metal strip, which in turn is exactly the same as that of the finished part. It will be evident, therefore, that there can be no folding over of the plate, in place of which the metal is made to flow in due proportion, so as to fill every part of the

space between the tools, which space is of exactly the same extent as that of the cubic capacity of the blank. The proper flow of metal is induced, as already stated, by the contour of the top edge of the mold. Whatever doubling-over tendency there may be is converted into end pressure in lines parallel to the surface of the part, or, as it may be termed, an "upsetting" or "jumping" action.

It may be pointed out that naval architects are becoming strongly alive to the virtues of bending over or flanging plates in the building of steel ships, in place of riveting on angles or reverse bars; hydraulic machines of large size are now being manufactured for this purpose, especially in the case of bending over floor-plates and transverse divisions for double bottoms. It is impossible, however, from the nature of the case for shipbuilders to have at their command such beautifully designed machines and such accurately worked-out practice as that in use at the Leeds Forge.

It should be stated that for many years past the Great Western Railway have used steel underframes for rolling stock, but these are not pressed in the manner followed by the Leeds Forge. There is, however, an important plant at Swindon for constructing these underframes, and the success attained with them shows that steel is a suitable material for the purpose.

The Leeds Forge Company on this principle are the same in general design. The railway companies specify the dimensions of some of the parts, and that circumstance naturally goes far to determine the weight; but the Leeds Forge Company very emphatically state, as the result of experiment and experience, that by proper distribution and formation of the parts, and by the use of suitable material, the section of the bars may be such as to reduce the weight of an underframe very considerably, as compared with underframes of wood, iron and steel, built up in the ordinary way with channel or other bars, fastened together by means of angle irons. Details in regard to this matter will be given later. The number of separate pieces used with Fox's system is said to be less than one-half that required with well-made underframes of the present ordinary types. In all types of wagons with these underframes the tares are less than half the gross weight, including the wagons and full load, whereas in wooden underframes the tare seldom approaches so low as half the gross weight. The reduction in weight of an underframe made on this principle is about 25 per cent., as compared to frames of ordinary channel steel, in which the attachments are made by angles, gussets, knees, etc. The decrease in weight is not, however, the only advantage, for there is an increase in strength and a reduction in parts, making the underframe simpler to construct, as already referred to. An instance of this may be given in the case of a foreign railway, where competitive designs were invited from various makers, the order going to the Leeds Forge. In the stock which the Company proposed to use the underframes were made of steel, and consisted of 68 pieces. By the adoption of the pressed steel underframes the number of pieces was reduced to 13; the weight at the same time was reduced from 19 cwt., 3 qr., 21 lbs. to 13 cwt., 7 lbs., a saving of between 6 cwt. and 7 cwt., or about 35 per cent. In addition to this the number of rivets was reduced from 282 with the old arrangement to 104 with the new; while the number of rivet-holes was brought from 680 to 220.

Fig. 9, page 262, is an illustration of a 20-ton truck, with bogies which have been designed to compete with the American Diamond bogie design, which was supposed to be the type that possessed the virtue of lightness above all other forms of construction.

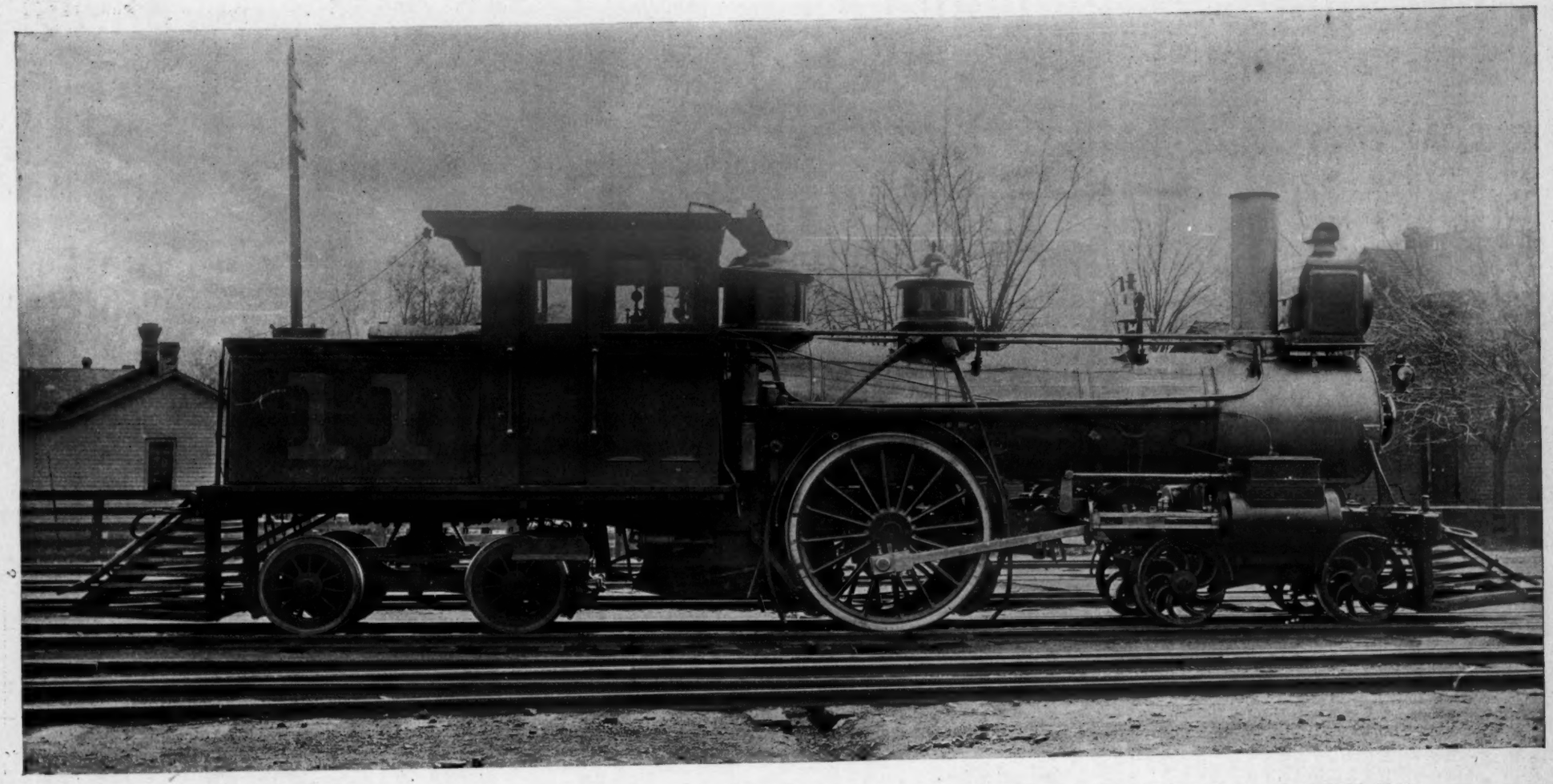
One of the earliest to appreciate the merits of pressed steel underframes was the late Sir George Berkley, President of the Institution of Civil Engineers, he having introduced the system largely in his work for the Natal Government railways. The pressed steel bogie frames have been in use on the Natal Government Railway since 1890, and orders for a fresh quantity were repeated a short time ago; the gauge is 3 ft. 6 in. On the Mexican Railway, of which Sir Alexander Rendal is the Consulting Engineer, the pressed steel bogie frames have also been for a considerable time used.

English railway engineers have been reproached with having lost sight of the important question in railway economics, of the amount of non-paying load that is hauled by the locomotives. Our critics say that, having a long purse to draw upon, our engineers have not troubled themselves to do the best that could be done from an economical point of view. There is no doubt that in the United States engineers have been more successful in reducing the tare of wagons in terms of the full load. The conditions of traffic in this country are different to those of America, but even in the United States it is questionable whether the size of goods wagons has not been carried to an undesirable extent, and that very frequently very big trucks are run with comparatively small loads, so that the actual weight of wagons as compared to the actual weight of goods carried is sometimes in excess of that of English railways. In this country we are bound to a great extent to our smaller goods wagons by the nature of sidings, etc., which are not suitable for long wagons, but there are signs of change in this respect, and the Manchester, Sheffield & Lincolnshire Railway are working in this direction. Indian railway engineers have of late turned their attention largely to this question of dead load, and they look forward to a reduction in the weight of rolling stock to enable them not only to carry the present traffic, but to provide for an increase of traffic for many years to come, using only the existing power and the present permanent way. The Leeds Forge have constructed for Sir George B. Bruce a number of carriage underframes and bogies, which have been sent to India, and also some open platform wagons, made entirely of pressed steel.—*Engineering.*

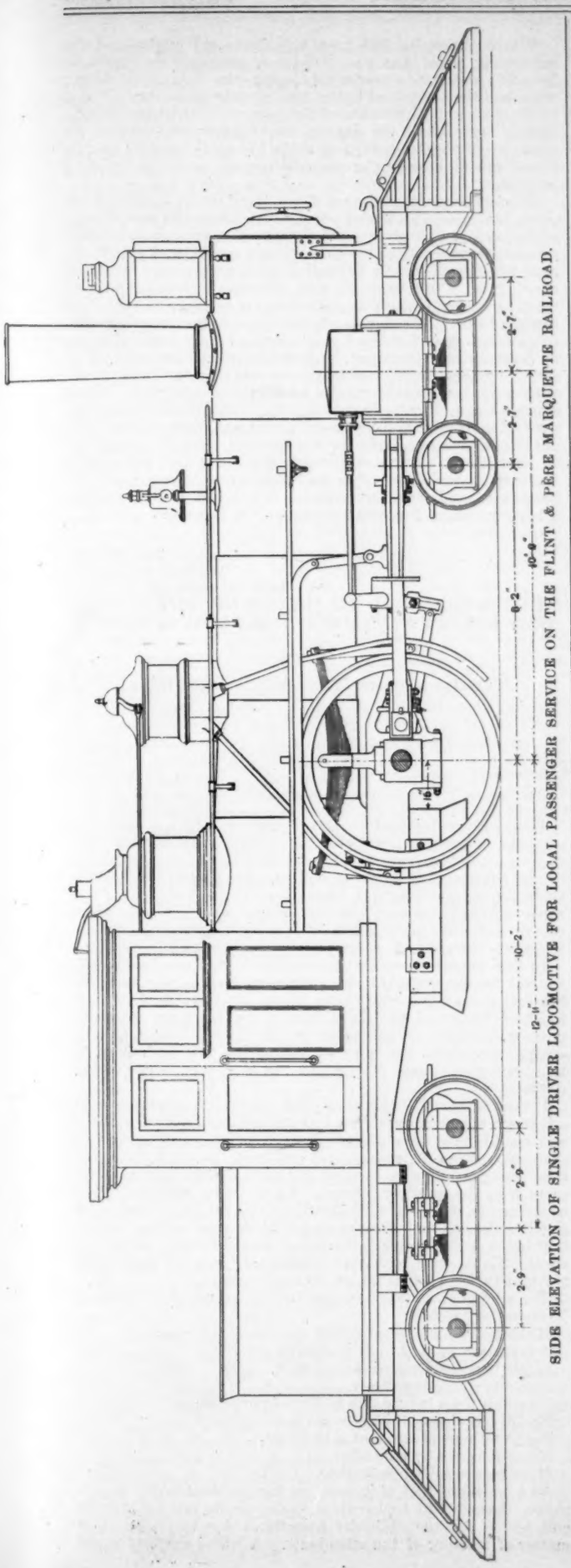
LOCOMOTIVE FOR LOCAL TRAFFIC ON THE FLINT & PERE MARQUETTE RAILROAD.

MR. T. J. HATSWELL, Master Mechanic of the Flint & Père Marquette Railway, has some engines in service hauling local passenger trains between Saginaw and Bay City, in which only one pair of drivers is used. Our full-page illustration on page 264 is a reproduction of a photograph of one of the engines. The side elevation shows the detail of construction. These engines are doing remarkably good work in the passenger service between the two points named, hauling trains ranging from two to six cars on fast schedule time. The line running from Saginaw to Bay City is a branch, and is operated by separate engines, from those working the main line traffic. The engine, as shown, is a double ender. It is easily handled, and has the neat appearance in running of all single-driver engines, giving perfect satisfaction in the service for which it was designed. The following is a list of dimensions and detail of the engine:

Kind of fuel used	Bituminous coal.
Gauge of road	4′ 8½″
Total estimated weight of locomotive in working order, including two men	80,000 lbs.
Total weight on driving-wheels	40,000 "
" wheel base, including tank	29′
Distance from center of main driving-wheels to center of cylinders	10′ 7¼″
Transverse distance from the center of one cylinder to the center of the other	6′
Diameter of H. P. cylinder and stroke of piston	15″ × 22″
Horizontal thickness of piston over piston-head and follower plate	5″
Kind of piston packing	Dunbar.
Diameter of piston-rod	2½″
Size of steam-port	1½″ × 14″
" " exhaust-port	2½″ × 14″
Greatest travel of slide valve	5½″
Outside lap of slide valve	1″
Inside lap of slide valve	3/16″
Throw of upper end of reverse lever from full gear forward to full gear backward, measured on the chord of the arc of the reach rod-pin throw	14½″
Sectional area of opening in each steam pipe connected with cylinders	15.9 sq. in.
Sectional area of opening in each exhaust pipe connected with cylinders	23.75 sq. in.
Diameter of driving-wheels outside of tires	67½″
" " front truck-wheels	30″
" " tank "	33″
Size of main driving-axle journal, diameter	7″
" " truck axle journals, diameter	5″
" " main crank-pin journals, diameter and length	3½″ × 3½″
Length of driving springs, measured from center to center of hangers	5′ 7½″
Description of boiler	Belpaire.
Inside diameter of smallest boiler ring	3′ 7¼″
Material of barrel of boiler	⅜″ steel.
Thickness of plates in barrel of boiler	⅜″
Kind of horizontal seams	Lap triple riveted
" " circumferential seams	" double "
Material of tubes	" welded iron.
Number " "	133
Diameter of tubes outside	2″
Distance between centers of tubes	2¾″
Length of tubes over tube plates	11′ 1″
" " fire-box	4′ 5″
Width of fire-box	2′ 10″
Depth " "	5′ 2⅛″
Water space, side of the fire-box	4″
" " back of fire-box	4″
" " front of fire-box	5″
Material of outside shell of fire-box	Steel.
Thickness of plates of outside shell of fire-box	⅜″
Material of inside fire-box	Steel.
Thickness of plates inside of fire-box	⅜″
" " " back end of fire-box	⅜″
" " crown plate	⅜″
Material of tube-plates	Steel.
Thickness of front tube plates	⅜″
" " back tube plates	⅜″
How crown plate is stayed	Stay bolts 4¼″ pitch.
Diameter of dome	30″ outside.
Height of dome	9′ 10″ inside.



SINGLE DRIVER LOCOMOTIVE FOR LOCAL PASSENGER SERVICE ON THE FLINT & PÈRE MARQUETTE RAILROAD. DESIGNED BY MR. T. J. HATSWELL, M.M.



SIDE ELEVATION OF SINGLE DRIVER LOCOMOTIVE FOR LOCAL PASSENGER SERVICE ON THE FLINT & PÈRE MARQUETTE RAILROAD.

Maximum working pressure per sq. in	130 lbs.
Kind of grate	Locomotive rocking shaking grates
Width of opening between bars	⅜"
Grate surface	12.51 sq. ft.
Heating surface in fire-box	84.49
" " of the inside of tubes	702.38
Total heating surface	786.87
Kind of blast nozzle	Single.
Diameter of blast nozzle	3½"
Smallest inside diameter of chimney	16"
Height from top of rails to top of chimney	12′ 9"
" " " " " " center of boiler	6′
Distance from center to center of truck wheels of tender	5′ 6"
Water capacity of tank (in gallons of 231 cu. in.)	1,200.
Coal capacity of tender or fuel-bin	2 tons.
Total wheel base of engine and tender over all	42′ 1"

ELECTRIC POWER INSTALLATIONS IN ENGINEERING AND IRON WORKS.

At the meeting of the Cleveland Institution of Engineers on the 9th inst., at Middleborough, Mr. J. Phillips Bedson, of the new Cleveland Wire & Iron Works, Middleborough, read a paper by Mr. D. Selby Bigge, of Newcastle-on-Tyne, on this subject. The following is an abstract: The author said that electricity had for many years come under the notice of civil, mechanical, and general engineers; but, as a rule, this had been in connection with lighting. For some four or five years electricity had been employed as a motive power in connection with mining operations, such as hauling, winding, pumping, ventilating, coal-cutting, drilling, and other minor uses. The application of electric power had, therefore been confined chiefly to what might be called long-distance transmission; in some cases over many miles, as in the case of mining work or traction. The general tendency had been to consider the application of electric power in those cases only where the power had to be conveyed a considerable distance. The writer desired in his paper to draw the attention of engineers to short-distance transmission or concentration of power. In order fully to grasp this idea, he would take the case of any large engineering works in which the motive power was derived from a number of scattered and auxiliary steam-engines, which in some cases were used for driving shafting in fitting shops, and in other cases were applied to various machine tools, winches, traveling cranes, overhead cranes, hot saws, cold saws, rolls, forge blowers, punching and shearing machines, straightening machines, planing machines and the numberless other apparatus which were daily employed in engineering establishments. Cases were often found in which numbers of pumping and shearing machines were driven by means of belts and pulleys, receiving their power through long lines of main shafting and countershafting. In many cases the boilers necessary for producing steam for all these engines, were situated at a considerable distance from them, and the steam had to be conveyed through long lengths of pipe. The boilers, instead of being all concentrated together in one battery, were scattered about the works. Such were the conditions daily met with when looking through engineering establishments.

The writer then set himself to show how short-distance electric power installation could be advantageously adopted. and what great economies could be realized by a concentration of all that scattered power.

1. Taking the case of separate engines for driving individual machinery, it would readily be admitted by all engineers that much better steam economy could be obtained from the employment of one large highly efficient engine than from a large number of small engines, which for many reasons were not of so efficient a character, the steam consumption in each of the small engines being proportionately four to six times greater than it would be in a large engine of a triple-expansion condensing type.

2. Taking the case of a machine shop driving off shafting, there was considerable loss incurred in transmitting power through long lines of mains and counter shafting with all the attendant gear wheels, bearings, pulleys, belts, etc., this loss varying from 20 per cent. up to 60 per cent. of the power transmitted.

3. The disadvantage of having boilers at long distances from the engines they had to drive did not need to be recounted, nor the inconvenience of having boilers scattered about, and the inefficiency of working at a low pressure.

All these disadvantages could be obviated by a well-considered application of electric power. The writer proceeded to demonstrate the way in which this could be realized. The first thing would be to find out the individual power of all the steam-engines in the works and the total H.P. Having arrived

at the unit of power to adopt, the next thing was the site that the generating plant should occupy. If in the neighborhood of a river or other water, the plant should be placed in such a manner as to afford every facility for condensing purposes, and if waste furnace gases were available the plant should be placed so that the boilers would derive full benefit from gas firing. The site need not necessarily be in the works at all, as distances not exceeding half a mile, or even a mile, were, electrically speaking, not of great importance when compared with the advantages to be derived from gas firing and condensing. The next question to be considered was what form of engine and dynamo should be adopted for generating the electric power. The boilers should work at high pressure—150 lbs. up to 180 lbs.—the engine should be triple-expansion, and be coupled direct to a dynamo capable of giving out a power equal to the full output of the engine. He would assume this to be 500 H.P. With dynamos of this size and power there would be three types of engines to select from, running at three different speeds: First, a horizontal Corliss engine, running at 80 revolutions per minute, and coupled direct to a dynamo, of which the armature would form the fly-wheel of the engine; second, an engine of the triple-expansion marine vertical type, also coupled direct to the dynamo, and running at a speed of 150 to 180 revolutions a minute; and, third, an engine of the high speed electric lighting, or Willans type, and running at a speed of 300 revolutions per minute. In any of the above-named cases the electric power should be generated for not more than 1½ lbs. of coal per indicated H.P. The current would then be led from the generating dynamo to a main switch-board in the engine-house itself, and by circuits would be brought back from the various motors about the works to this one central board, in which measuring instruments would be placed so that the attendants in charge could see at a glance what each individual motor or set of motors in the works was doing at any time of the day or night. The cables from the main board should be taken to minor distributing boards, or sub-stations, if the works were of any very great extent, and further branched off again to the different motors. The cables, in some instances, would be run overhead, and in others in culverts or channels underground. It was most important that the motors, etc., should be kept as dry as possible. Where necessary each machine tool could be provided with its own electric light.

In works not exceeding 800 yds. in length, the efficiency of such a plant would be made up as under: Loss in main generating dynamo, 7 per cent.; in mains, 3 per cent.; in motors, 15 per cent.; total efficiency, 75 per cent.

With an ideal electric-power installation there would be self-contained electric machine tools, in which the motor would be embodied as part of the machine; but in existing works this was difficult to realize, and the method was either to drive by belt on to existing fly-wheels, or else couple the motors direct by means of gearing.

The very small loss in distributing the power through cables was a matter which must be evident to all engineers, when compared side by side with long lengths of shafting or of steam-pipe, in which condensation and loss of power were bound to take place. Considerable economy in wages could be effected by the application of electric power, especially in works where there were a number of boilers scattered about. These scattered boilers could generally be entirely done away with, and replaced by one or two large high-pressure boilers adjoining the generating plant.

In establishments where the work was of an intermittent character, electricity was particularly applicable. Under present circumstances large numbers of outlying machines were kept constantly running whether in operation or not. These took almost as much steam when running light as when doing their work. The amount of coal wasted during the year in keeping idle machinery running was very considerable. A large proportion of this waste could be avoided by the use of electric motors which could be switched on or off instantaneously.

Another very practical application of electricity was the driving of all forms of cranes and winches. Almost every modern crane in America was electrically driven—at any rate in those places where electric current was available.

A further advantage of electric power was the small size and weight of the motors themselves and their foundations.

As to the cost of the up-keep, for installations of 300 H.P. and upward, it would be 5 per cent. per annum on the capital outlay, though with care and attention it should not exceed 3 per cent.; the bearings, brushes, and commutators were the only wearing parts of a dynamo or motor. There was hardly any depreciation in the copper cables, and copper would generally find its value. Switching apparatus required seldom renewing if properly constructed.

Where electricity had been applied to old works, and the generating plant was not of such a character as would be found in an entirely new works, economies from 30 to 60 per cent. had been obtained in the coal consumption, entirely due to the electrical distribution of the power. The writer thought that it was almost the duty of an engineer who wished for economical working results to study the application of electric power when extending or remodelling old works or building new ones.

The writer mentioned that three large works in Middleborough had already adopted or were adopting the use of electricity as a motive power, and several other manufacturers had the matter under consideration. He expected that within the next five months nearly 1,000 H P. of electric power would be running in Middleborough, and this was far in advance of what had been done in any other town in this country. As regarded the application of electric power, the American and continental manufacturers were perhaps far ahead of ours. In Belgium and Germany large works were operated exclusively by electricity, and had been running for three years with very remarkable results as regarded economy. There was no great difficulty in constructing dynamos of almost any size. The largest that had been constructed was a 2,000-H.P. multipolar dynamo, built by the General Electric Company, of New York. It was employed in running the Intramural Railway at the World's Fair, and was coupled direct to a compound condensing Corliss engine. It weighed 35 tons, and the efficiency obtained was 96 per cent.—*The Engineer.*

MEETING OF THE MEMBERS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The Use of Water-Tube Boilers in the Navy.

By Walter M. McFarland, Past Assistant Engineer, U. S. N.

Having been honored by the Committee which is in charge of these monthly meetings of the Society with an invitation to prepare a few remarks to serve as a basis for a discussion of the subject of water-tube boilers, with special reference to their use in the Navy, I have pleasure in complying; but must state at the outset that the request came at a time when pressure of other matters did not give me the leisure necessary to go into the subject as carefully as I might have wished.

In this matter of water-tube boilers I shall confine myself to the type known as tubulous or coil boilers, merely mentioning that years ago a water-tube boiler, invented by Engineer-in-Chief Martin of the Navy, was in use for some years and gave satisfaction. This, however, was a shell boiler, and its weight was about the same as that of fire tubular boilers, so that it does not come properly in the category we propose to discuss.

It may be stated at the outset that coil boilers possess certain advantages which recommend them for use in naval vessels, and would make their adoption a certainty but for one or two features. From their successful use naval designers have had their ultimate adoption in mind and have watched the development with the greatest interest. In our own Navy extended experiments were made by Boards of Naval Engineers under the direction of that great engineer Isherwood on the Herreshoff boiler, so that full information was possessed in this respect. Experience with them, however, was not such as to warrant their adoption for use in large vessels.

The advantages offered by coil boilers for naval vessels may be stated as follows:

Reduction of weight of boiler and contained water.
Adaptation to very high pressures.
Safety against disastrous explosion.
Rapidity of raising steam.
Freedom from injury due to forced combustion.
Facility in renewal when worn out.

Against these advantages is to be set:

Greater injury by corrosion.
More care required in feeding.

As a matter of fact, if it were not for the trouble due to corrosion, there would be hardly anything to be said against the coil boiler, for the difficulty sometimes due to feeding is a matter of training of the attendants. A friend recently wrote

me in regard to the boilers of the *Monterey*, where each fire-room has two Ward boilers and one cylindrical: "One feed-pump can be made to supply both Ward and Scotch boiler in battery, but every chump who calls himself a water tender can't do it."

It is hardly necessary to elaborate the advantages, but it may be remarked that the reduction of weight is the greatest. For the last 10 years the demand on the designer of naval machinery for increased power on reduced weight has been growing stronger, and although forced draft does materially reduce the boiler weight, it has not been an unmixed blessing. When we reflect that coil boilers weigh less than half as much as cylindrical ones for the same power, and that they can be forced to any extent without danger of injury, we see how desirable the coil boiler becomes.

As in the case with many other improvements in steam machinery, the Navy has followed rather than led outside practice. The reason for this is not hard to understand when we reflect that the officers charged with the carrying out of Government work have not the free hand of those in civil life. A designing engineer frequently has unusual opportunities given him by the fact that some yacht owner demands exceptional speed, and is willing to sacrifice almost everything to attain it. Such a case would offer a splendid opening for the trial of a tubulous boiler.

In 1885 the late Admiral Simpson of the Navy, who had been President of the Naval Advisory Board, in an inaugural address as President of the Naval Institute, made the remark that the great necessity for improvement in naval vessels was in reduction of weight of machinery, and that he thought it lay in the direction of using Herreshoff boilers rather than those of the ordinary shell type. He doubtless selected the Herreshoff boiler for the reason that some launches with this boiler had been used in the Navy, and it was the only one with which he was familiar. In that Society it was not considered the proper thing to discuss or criticise the inaugural address of the President, so that no reply was made to the remark at the time, as could very readily have been done; but at an adjourned meeting which I attended, Passed Assistant Engineer Kafer, then attached to the Bureau of Steam Engineering, did discuss the subject in an informal way, and he remarked that the Engineer-in Chief of the Navy, who was then Mr. Charles H. Loring, who has since been President of our Society, was fully alive to the promise of tubulous boilers, but that he was not willing to stake his professional reputation on their success by powering a vessel of any size with them. He was perfectly willing, Mr. Kafer said, to advocate their adoption experimentally on a small vessel, but it must be understood that it was an experiment; and he called attention to the fact that it was a very easy matter for people who had no responsibility attending their recommendations to advise certain lines of action, while the ones on whom the responsibility came were necessarily compelled to be more conservative.

Not very long after this a test of a Ward launch boiler was made by a Board of Naval Engineers. Mr. Ward having offered his boiler for test and agreed to defray the expenses, and this test showed excellent results, both as regards economy of evaporation and power for a given weight. Herreshoff boilers had been used, as I have already said, in naval launches for some time, but they were not entirely satisfactory in every respect and had not been generally adopted. The test of the Ward boiler gave information of a type of boiler adapted to all the requirements of naval purposes, and in 1888 several of them were fitted to naval launches. Their success was very marked, and since that time no new boats have been built which have not been fitted with coil boilers, although other types besides the Ward have been used, a number of Towne boilers having been fitted, and also one or more each by Roberts and Almy. Our experience with the Ward boiler has been more extended than with any of the others, and I have heard a number of officers who have had experience with it in different portions of the globe testify uniformly to their entire satisfaction with it.

About 1888 the Navy Department made a contract with the Herreshoffs to build the *Cushing*, and the design in every respect was left to them. At first it was the intention to use Herreshoff boilers, but subsequently that firm, having acquired the control of the Thorneycroft patents for this country, requested and obtained permission to use Thorneycroft boilers in the *Cushing*. In the early part of 1890 the *Cushing* was tested officially, after having been given a number of private tests by the builders. The official test as well as the others were very satisfactory, and showed the boilers to fulfill the requirements of the case with great satisfaction. In the *Journal of the American Society of Naval Engineers* for 1892, Chief Engineer Isherwood has written an article about the *Cushing*, which gives an extended account of the boat and all her various trials.

In the fall of 1890 a series of tests of one of the boilers of the *Cushing* was conducted by a Board of Naval Engineers under the Presidency of Chief Engineer Loring, and a large amount of valuable information obtained. A copy of the report of this Board was published in the report of the Bureau of Steam Engineering for 1891.

In 1888 Engineer-in-Chief Melville of the Navy urged upon the Secretary the importance of experiments on a large scale, to determine the suitability of tubulous boilers for use as a part or all of the boiler power of our naval vessels, and in accordance with his recommendation the Secretary sent out an invitation to all the builders of coil boilers in this country, inviting them to submit plans and prices to meet specifications which had been prepared by the Department. Some 15 or 20 replies were received, and in 1889 an invitation was sent to the makers of those boilers which appeared adapted, asking them to suggest a time when they would be ready to have their boilers tried. Four of the firms who had previously replied acknowledged the receipt of this letter, but only two of them actually submitted boilers for trial, Mr. William Cowles and Mr. Charles Ward. A boiler made by each of these gentlemen was tested by a Board of Naval Engineers under the Presidency of Chief Engineer Loring, and the report giving the results was published in the report of the Bureau of Steam Engineering for 1890.

As a result of this competitive test the boiler submitted by Mr. Ward was adjudged to have given the best performance, and in accordance with the terms of the proposition under which the tests were made a contract was concluded with him for supplying boilers for the U. S. S. *Monterey*, to furnish the steam for 4,200 H.P. in triple-expansion engines. The trial of the *Monterey* took place in 1892, and the boilers gave a very good account of themselves, the engineer officers who attended the trial speaking in the highest terms of their creditable performance. The trial of the *Monterey* was not in every respect a complete success, because the H.P. of the machinery fell slightly below that required by the contract, and in explanations as to the cause of this deficiency there was some difference of opinion. There was no means of telling certainly how much steam was supplied by each kind of boiler (there being two single-ended cylindrical fire tubular boilers besides the four Ward boilers). The naval engineers who were present attributed the failure to attain the H.P. to lack of skill on the part of the firemen, while I have understood that engineers connected with the Union Iron Works, who built the vessel and all the machinery except the Ward boilers, thought that the trouble was partly due to the coil boilers. They thought this was not due to any defect in the boilers themselves, but to the fact that their position in the ship was such that it was difficult to clean the fires and keep them in the best possible condition, and that on this account there was a falling off.

It is to be noted in connection with this trial that a very high air pressure was used at times, as much as 4 in. of water, and although some leaky tubes were developed in the cylindrical boilers, the coil boilers showed no signs of injury in any respect, and after the trial were as tight as before.

This comprises the actual experience in use in our own Navy up to date. The *Ericsson*, a sister torpedo boat to the *Cushing* with a few changes, now building at the Iowa Iron Works, is to have Thorneycroft boilers, while four third-class torpedo boats for the *Maine* and the *Texas* are to have Mosher boilers.

In a design elaborated at the Bureau of Steam Engineering last year, coil boilers in connection with cylindrical are to be used in supplying a quadruple-expansion engine. The coil boilers will furnish steam at 250 lbs. to the high-pressure cylinder, while the cylindrical boilers will supply steam of about 150 to 160 lbs. to the first receiver. The type of coil boilers to be used has not yet been settled, as it is the policy of the Department to permit the contractors to make the selection in the first instance subject to approval.

Last summer at the International Engineering Congress a paper was read on the subject of coil boilers in general by Mr. Ward, and in the discussion of that paper I remarked that it appeared to me that the most important question in connection with coil boilers was their longevity. Being composed entirely of tubes of small diameter and quite thin, it naturally follows that corrosion will be a very important factor in their usefulness. Mr. Ward has informed me personally that some of his boilers which have been used on Western rivers, and have never been exposed to the influence of salt water in any way, have already been in service for over 10 years and are still in excellent condition. There are also some in use on yachts, I believe, which have had six or seven years' service, and the revenue cutter *Manhattan* has a boiler which was put in in 1888, I believe, and is still in good condition.

The launch boilers that we have used in the Navy have been satisfactory in respect to longevity, as none of them have as yet given out, except in an occasional tube here and there, which were easily repaired. The *Monterey*, of course, has been too short a time in service to have any question of longevity raised The boilers of the *Cushing* have now been built at least five years, and they are in excellent condition, and have shown no signs of pitting or other serious deterioration.

The question of corrosion assumes a somewhat different phase for coil boilers from the same phenomenon for shell boilers, because in the latter the tubes form a relatively secondary part of the boiler, while in the former they practically are the boiler; and, as has been repeatedly pointed out, a leaky tube in a shell boiler can be plugged while steam is up; but this cannot be done in the coil boiler. There is no reason why the tubes of a coil boiler should deteriorate any more rapidly than those of a shell boiler, and in many types they ought to last longer because thicker.

Mr. Ward has stated that one of his boilers built nearly 14 years ago has lost only one tube, while a number of other boilers have been in use for six or seven years and given no trouble. Mr. Roberts also states that the first of his boilers built about 15 years ago has never given any trouble from corrosion. It is probable, however, that most or all of these boilers have been carefully kept free from the deleterious action of salt water, although a good many of these boilers are fitted in yachts about New York.

I might, then, sum up our experience with coil boilers by saying that as regards lightness, rapidity of raising steam, safety against disastrous explosion and safety against injury by excessive forcing, they have given entire satisfaction.

The experiments on the Ward and Cowles boilers in competition, and those on the Thorneycroft boilers of the *Cushing* and the Ward boilers on the *Monterey* show conclusively that coil boilers will stand any amount of forcing without injury, as these were all subjected to air pressures of 2 in. and over for long periods without a single leak being developed. We also made a severe test of a small Towne boiler at one of our Navy Yards by running it for several hours under forced draft, then hauling fires as quickly as possible and turning a stream of cold water on every part of the boiler from a hose, so as to get the full effect of sudden contraction. Not a leak developed anywhere.

With regard to longevity, it is as yet too early to speak, but such experience as we have had leads us to believe that with proper care to guard against corrosion they should have a reasonable life.

In this connection it is worth noting that the Belleville boiler has been in use in the French Navy for at least 10 years, and the experience with it has apparently been so satisfactory as to lead the English Government to place an order for a set of these boilers for the large English cruisers *Powerful* and *Terrible*, which are to have about 30,000 H.P. each. The Belleville boiler differs very materially from the coil boilers invented in this country and all others invented abroad, in having its tubes of very large diameter and much thicker than those in any other coil boiler. The tubes are generally about 4 in. in diameter, and the lower row are about three-eighths of an inch thick, and no tubes are less than .20 of an inch. This undoubtedly accounts for the long life of these boilers, as it is manifest that a trifling bit of corrosion which would go clear through a thin tube will only affect these thick ones half as much, and will still leave them serviceable for a long time. The great trouble with the Belleville boiler, compared with most other coil boilers, is its weight. We shall doubtless shortly have some valuable data in regard to this particular boiler from the experience with the fast express steamers on the great lakes, which are to be fitted with boilers of this type.

The number of coil boilers is almost legion, and every inventor brings out some change in his own type at frequent intervals. I presume it would be safe to say that nearly all that are designed with any regard to a good circulation will give good results, and such has certainly been our experience with those thus far used in our Navy. It is curious to observe, however, how ideas change in regard to what is necessary to secure a good circulation. Mr. Ward has always claimed that you could put your down current almost anywhere if the feed went into it, and that, of necessity, if the water went up in some tubes it must come down in others. For awhile Thorneycroft, Mosher and some others provided down cast pipes entirely outside the boiler, but they have now abandoned that plan.

I feel that I must apologize for the incompleteness of this paper, but I would refer those who desire an elaborate investigation of the subject to the paper by Mr. Ward, read before the International Engineering Congress, and published in the *Proceedings of the Division of Marine and Naval Engineering and Naval Architecture*, and to papers read last year and this before the Institute of Naval Architects in England, by Mr. J. T. Milton, Chief Engineer Surveyor to Lloyd's. The subject is a thoroughly live one, and I am glad the Society has taken it up. A number of our members have much greater personal knowledge of the characteristics of particular types of these boilers than the writer, and it is to be hoped that during the discussion on this subject they will give the Society the benefit.

DISCUSSION.

Mr. Boyd: Several years ago I was engineer at the Atlantic Works, and we put in the first Belleville boilers that were put in in this country. They were put in the yacht *Shearwater*, and the objection then raised was their weight. We had no very good comparison at the time, but those boilers performed very successfully. One winter they went on a cruise to the Caribbean Sea, and for about three weeks they were not free from salt water. When the boiler was opened I went down and examined the tubes carefully. There was no deposit of salt, and there were no apparent defects in the boiler. She was sold about two years ago by her owner, and I think has been running in New York since then. The owner of the vessel, Mr. Forbes, built a yacht of about double the capacity, and he put in two Belleville boilers and then two small donkey boilers. Those boilers have been in use now three years, and so far as any internal or external examination can be made, they are apparently as good as the day they were put in. We are so much interested in the subject in Boston that we are investigating it, and probably will undertake the building of Belleville boilers there under the Belleville patents. From our experience, without going into detail at all, we think it possesses qualities that are not possessed by any other multitubular boilers. The experiments made by the Government on the *Shearwater* were made to test the rapid evaporative efficiency with 100 lbs of steam only. The Belleville system is to carry from 200 to 250 lbs., and then through a reducing valve to reduce the pressure in the engine. I think they are to carry 250 lbs. on their boilers and 180 to 200 lbs on the engines. I am very sorry that I did not think of coming to-night because I might have brought some dates in regard to the time the boilers have been in use and the repairs on them. But nothing, I think, except the renewal of gaskets has been expended on any of the boilers I speak of. I am sorry to say I cannot say how much these boilers weighed per H.P. I think, in the report published by the Navy Department, that they gave fully all the weight that was credited to the boilers, and my impression is that it weighed between 15 and 20 per cent. of what the Scotch boiler would. The claim is that when the pressure gets to 200 lbs. the weight of the boiler is very much less.

Mr H. De B. Parsons: I have had a little experience with water-tube boilers, especially in yachts. I am a believer in the water-tube types, although my remarks would probably appear as if the water-tube type was not the best. Yacht boiler service is probably the hardest for the boilers of any marine service. The consequence is that the boilers in a yacht of the water-tube type do not usually last more than two years. At the end of the second year some trouble is developed. I had a yacht that had a water-tube type boiler of the Herreshoff pattern. It was not the old-fashioned Herreshoff, fed at the top, but it was the boiler that they got out immediately after that. The first of their type fed at the bottom. The boiler lasted about two years, and the third summer was replaced with a boiler of another design. That boiler was absolutely worthless; and my services were retained to find out the trouble, and I condemned the whole thing on the ground that it was too small for the engine. The boiler designer had so much confidence in his boiler that he stretched the point of H.P. per square foot of grate, and in consequence we could not do anything with it. We put the boilers on. The yacht was supposed to run with forced draft, and I took it over the four-hour trial trip as specified, and nothing was ever seen of the water. I trusted to the Worthington duplex feed pump and to the engineer's experience, who had been with the yacht about three years, as to the speed the pump could run at, and we let the pump go at that speed, every now and then feeling a little cock on the pump to see if it was pumping water. The engine apparently was taking steam all right and exhausting all right; and when our trial was over, about three or four minutes after the engine was stopped, the water came back and stood about an inch above the bottom of the glass gauge. During the four hours it was absolutely out of sight—never came back at all; you couldn't get it back. Everything blew steam. The boiler was condemned.

In another case a yacht was furnished with a Ward boiler which wore out in about three or four years. I was retained,

and the owner put in four boilers in place of the one large Ward boiler, of the Roberts type, against my wishes. The grate surface was increased from about 56 to 64 sq. ft. with four boilers. Result: the fire-room was so hot you could not stay in it; and as the boilers backed up against the engine-room, you could not stay in the engine-room. The boilers would give no steam at all. The engine was three-cylinder compound, 20 in. × 24 in. for the high pressure, and it took more steam than the four boilers could give. The consequence was that the yacht was laid up all summer and never used. The boilers were put on the dock and replaced with the old Scotch boiler which I recommended originally. Although the grate surface is only 50 sq. ft., the Scotch boiler gave plenty of steam to run the engine.

The result of my experience from these cases and others is this: If you are going to use a water-tube type of boiler, you have got to have plenty of grate surface. They need more grate surface than the other type. I know they will stand forcing, according to the tests; but my experience does not indicate that they will give in ordinary practice the H.P. per square foot of grate that you can get out of the old-fashioned boiler. The reason of that is probably that there is no storage of steam, no steam space, and no energy stored in hot water, and the consequence is when the steam once gets down you cannot bring it up very well; the engine will take it faster than it is made, unless you have boilers of ample size. My first effort in boiler designing was an absolute failure. It was such an effort as most young men make in attempting to design something which they know very little about. I undertook to design a coiled boiler. My ignorance led me to use tubes of different sizes. Result: the small tubes evaporated faster than the larger ones, and the consequence was that there was some sort of circulation—I don't know what. But the boiler acted very strangely. There was absolutely no water to be found anywhere in it. There was steam in it, but where the steam came from I do not know. Being the designer, I had to sit up with my creation, and it was no pleasant day that I spent with it on the Hudson River. I was very anxious to go back to the dock and get ashore and leave it, but they told me to keep on. They had not said the word more than twice when there was a terrible rattling inside and we could do nothing with it. The minute we would start again the small tubes apparently sucked everything out of the large ones and reversed the operations that were designed to take place. The water was forced back apparently into the large down-draft tube and there it stayed, and as fast as it came out it was evaporated and the steam in volume held it back. The result proves to my mind that you need a large water tube if you are going to use one for the sake of economy and for the sake of comfort, and that the circulation should be well designed so as to work as designed.

Mr. Kafer: The design of water-tube boilers has been to make steam on very little weight. If we were satisfied to make it as we were thirty or forty years ago there would be no water tubes in existence. But the problem now is to get maximum power from minimum weight, and that is the problem for the water-tube boiler. The great difficulty in the water-tube boiler is to get it perfectly accessible. With tubes readily removable repairs can be easily made, and it should be made to last a reasonable length of time—not to last the length of time that a Scotch boiler will last. I do not know of any one boiler in the market that will fulfill all the conditions and yet have maximum power for minimum weight. The great difficulty with designers has been to crowd too many small tubes in the space allotted to them, and for that reason they want to get rid of the weight of water. That is the chief advantage of the water tube boiler having small tubes. The Belleville boiler is a very excellent boiler to operate under natural draft. But if you will take a box coil and have a hot fire under the lower coil and burn 50 lbs. of coal per square foot of grate you will find trouble before you get up to the upper end. That is one reason why a Belleville boiler will weigh more than a Scotch boiler, or nearly as much as a Scotch boiler of the same relative H.P. under forced draft. The Belleville boiler must be operated at a lower rate of combustion than that at which the Scotch boiler can operate with perfect safety. With reference to the other types of boilers—Yarrow and Thornycroft and others—they all depend on natural circulation. It is well known that a boiler of that type will hardly evaporate as much water per pound of coal under ordinary conditions as the ordinary Scotch boiler. But if you could have an engine on the outside and force the water through the tubes, so that you knew when the shaft was turning the water was going through the tubes, you would accomplish perfect circulation, and yet you might have the tubes in such a position as not to have corrosion when the vessel was laid up.

Mr. Isherwood: The merits of the water-tube boiler have been very clearly stated in the paper read by the secretary, and its principal merit, of course, is the lighter weight. The vital defect about it—one which has been very little alluded to heretofore, if known at all—is that it is impossible to obtain with it the same economic evaporation that you can obtain with the ordinary shell boiler. That is to say, if you make the two boilers—the pipe boiler and the shell boiler—both with the same grate surface and the same heating surface, and burn the same quantity of coal in both per unit of time, it will be found that the pipe boiler gives about 10 per cent. less economic evaporation. That is to say, if one boiler will evaporate 10 lbs. of water to the pound of coal, the other will evaporate but 9 lbs. Of course there is a reason for this, and I think it is very easy to see. It arises from the air leakage in the case of the water-tube boiler. In the case of the shell boiler, no air, no exterior air, can get mingled with the gases of combustion. The only air that enters is that entering through the furnace in the ash-pit and over the bed of coal on the grate through the holes in the furnace door. Every particle of air that enters into and mingles with the gases of combustion after they have passed over the bridge wall reduces the economic evaporation of the boiler very largely. In the first place, it cools those gases so that they do not have the temperature upon the heating surfaces that they should, consequently cannot give the evaporation; and, in the second place, it requires a certain quantity of heat to force those gases out against the resistance of the atmosphere, the opposing resistance at the top of the chimney, which is also at the expense of the heat of the coal. The two things put together will make that difference about 10 per cent., as I have stated, of the economic evaporation of the two types of boiler. There is no practical way of excluding the air leakage; and while I am on this subject I will say that there is just the same difference of 10 per cent. in boilers set in brickwork. You take the ordinary boiler with straight tubes and the shell and you set it in brick-work. You have a brick furnace. You will never get the same economic evaporation from it as with a shell boiler—that is, the Scotch form of boiler—for the simple reason that there will percolate through the brick work setting a certain quantity of air very much larger than any one would suspect, and that reduces the economy of the evaporation. In the early days of my practice as an engineer I was confronted with the fact that all the boilers set in brick masonry gave a lower economic evaporation than those not so set. In other words, that the interior fired boiler gave a higher evaporation than the exterior fired boiler. I made quite a table of the results from all the boilers of the two types that I could obtain. A very great many of those experiments were made by me, and I took the mean of them and I found that they approached the 10 per cent. very closely. I did not at that time know the reason. I had not the faintest idea of it. I thought it was something in the type of boiler. But really I could not reconcile it. I had the same grate surface, heating surface and combustion of coal in both cases. I could not see why this difference should be for a long while. But the difference was there as a practical fact, and it was caused, as I afterward ascertained, by what I have stated—the in-leakage of air into the gases of combustion, cooling them and requiring more expenditure of heat to expel them from the chimney.

Now, let us see what, in a ship, a difference of 10 per cent. in the evaporation of the boiler means. It means a good deal more than appears on the surface. To develop the same power for the same length of time, you have got to carry 10 per cent. more coal in your bunkers. If you have a vessel that carries 1,000 tons of coal in its bunkers it has got to carry 1,100 tons if you replace the shell boiler with the pipe boiler. Now, that difference of 10 per cent. of course becomes more important as you carry more and more coal and make longer and longer voyages. That difference goes very far to counterbalance the saving of weight with the water-tube boiler. Of course upon the land, where the weight is of no importance, you simply lose your 10 per cent. of fuel. But on a ship you not only lose that, as far as cost is concerned, but you have got to carry this extra weight, and if you do not carry it you have reduced the steaming efficiency of your vessel that much.

In addition to this in-leakage of air, the radiation from the water-tube boiler is very much greater than from the shell boiler. In the case of the shell boiler the temperature is that of the water inside of the boiler; that is, the temperature which is on one side of the shell, the atmospheric temperature being upon the other. In the case of a water-tube boiler the temperature of the gases of combustion is upon one side of the shell or casing, and the same temperature of the atmosphere on the other. The radiant heat in a vessel with a water-tube boiler is intense compared with the radiant heat from the ordi-

nary shell boiler. Those are facts that have to be met, and we have to account for them in designing boilers. For small vessels, launches, torpedo boats, and that class of vessels, you have generally but one boiler, and you have plenty of air circulation around it where it can be kept clean and well cared for. If any repairs are to be made, it can be hoisted out by a few men on the dock and put back again. But it is a very different thing when you put an enormous power into a vessel and boilers of this type. As a general rule, they will probably last, under ordinary circumstances of sea practice, from two to three years. It is difficult to understand that they can last longer than that. I am aware that some boilers, like the *Cushing's* and a few others, have lasted much longer; but why? They have been protected by zinc. Large quantities of zinc have been put into them according to the practice of the Thornycroft people and others building those boilers. That answers very well. But it is very expensive. The simple question is, Will you pay in zinc or will you pay in boiler? But you have got to pay for the thing one way or the other. In the case of a water-tube boiler with its thin outside casing of sheet iron, apart from the great loss of heat by radiation, there comes the difficulty of repairing. Any person who has examined those boilers and has seen the wilderness of small tubes in them, the impossibility of getting at any one of them or at their joints, will see that to repair one you have got to lift it out as a general rule. You cannot find the place. It may happen to be an outer or an inside tube, and you can see it; but if it is any of the interior tubes that leaks it is impossible to tell. In the case of a vessel that is a very serious piece of business to have your boilers break down all at once at sea. What is required is durability. That is a very important point. In the case of the ordinary Scotch boiler, in which iron tubes or steel tubes will last from two to three years, you can always see when your tubes are going. It is only a matter of eyesight, and they are easily replaced. They are a straight tube. Your fireman can replace them with very little trouble. But it is a very difficult thing in a water-tube boiler in a large vessel, where you have to break all the connections, piping, everything, and actually lift the whole affair out, amounting to almost a reconstruction each time you attempt to make extensive repairs. Of course these are facts which will probably develop as these boilers come more and more into use, and I have no doubt they will come into use, but not permanently. I have very great doubts of that for anything like sea-going vessels. But, like all other physical subjects, we must depend on practice and experience for that purpose. The tubes of an ordinary tubular shell boiler will last from two to three years, and there is no imaginable reason why they should last any longer in the water-tube boiler, if as long. The old Martin boilers which we had in the Navy had vertical water tubes placed in the tube-box. When those tubes were made of iron the lower 6 to 9 in. began to rust out in less than a year. You had to commence renewal at about that time, and continue it constantly until they were all renewed. The upper part of the tube was not touched. They were as good as new. The lower part was entirely gone. Now, why was it? Simply this: the lower portion of the tubes was in ashes—the ashes from the coal deposited in that—and every time the boilers were cooled down there was a deposit of moisture on the surface of the tubes which trickled down into this ash and made a very corrosive lye, an alkaline solution which corroded the tubes very rapidly. Now, why should not this result take place in, we will say, the Thornycroft boilers, in which the lower parts of the tubes are vertical? They are inaccessible for cleaning; the ash and soot must collect and they must be damp at times, and there must be the same alkaline solution there that there was in the Martin boiler, only much more so, and why should it not produce the same effect of eating out the tubes? These are all matters which future experience will have to solve, but they are very important ones, and lead us not to be too sanguine on the success of the new class of boilers.

With regard to the Belleville boiler, that was first used in the French Navy as far back as the days of Napoleon III. Its use commenced then. It was put, I think, in some half-a-dozen vessels, and I do not know that the type of boiler has been modified at all since. That which was put in the *Shearwater* was exactly the same as used in the earlier French vessels, and every one of them was taken out. A number of years ago I was in France and visited every French dock-yard, and I conversed very freely with the French engineers stationed there. Their opinions to a man were against that type of boiler. They were all removed from the vessels. Since that they have been reintroduced, and with what success it is impossible for me to say, because the most instructive of such trials rarely ever reach the world. I mean the failures. We hear all about the successes, but we hear nothing of the failures; and that is one of the great difficulties we have in engineering, in getting at the correct statement of facts. Nevertheless, I think that the Navy should make large experiments on this type of boiler; build one of that type, try it thoroughly, stop at no expense on it, because the subject is well worthy the cost. But thus far we have not had any such experiments, not complete enough or extensive enough to enable us to form a real opinion upon it.

As regards the forcing of that type of boiler, it can be forced to any extent from the simple fact that the tubes are curved so that any difference of expansion does not injure the joints, but the tube merely curves or straightens more, while the joint remains unaffected, nor is the tube at all injured. In the Scotch boiler we have a straight, rigid tube, and whenever the temperature of that tube becomes much greater than the temperature of the water which surrounds it, it is sure to expand and force the tube ends through the tube-plates. That has always been the result when the attempt is made to force combustion in a Scotch boiler beyond 46 or 47 lbs. of coal per square foot of grate per hour, which is the maximum rate of combustion possible with it.

In the British Navy the attempt was made to go beyond that, and, as all the world knows, it was a failure. The boilers leaked a deluge the moment that rate of combustion was passed. Then it was stated that by means of a species of ferrules they succeeded in overcoming that difficulty. Well, that was one of the little romances that are sometimes used to cover a failure. The truth is, the so-called ferrules did no good whatever, and the proof of it was the fact that they were obliged to lessen the rate of combustion down to a point somewhere in the neighborhood of from 40 to 45 lbs., which is now the maximum at which those boilers are perfectly safe, while above it they are not.

These are about all the facts we have to go by; and what we want now are careful experiments made by competent people here in America, where we know the persons and can witness the processes. The subject is a very important one indeed, and I would be the last one to throw cold water upon it. Still, I think the chances of ultimate success are much better when all the difficulties are known in advance and can be calmly and deliberately provided against.

Mr. Eckley B. Coxe: I wanted to ask whether anybody knows what effect the increasing or decreasing the amount of coal consumed per square foot of grate surface, or the burning of coal, has on the relation of the temperature of escaping gases; and secondly upon the relation of the carbonic oxide and the free oxygen. From experiments I have made lately I am satisfied that a great many of the wonderful divergences that are found in experiments on boilers are due to the fact that that relation between the free oxygen and the carbonic acid and carbonic oxide varies very considerably. I have recently, in an experiment, had as high as 15 per cent. carbonic acid and no carbonic oxide. I have also had as much as about 9 per cent. carbonic acid and 8 per cent. of free oxygen, and still nearly 2 per cent. of carbonic oxide. Now, it is not necessary to tell anybody that that will make a good deal of difference in evaporation. The reason that I ask the question is that I cannot find much about the subject anywhere, and I would like to know about it. The question with me is this: When you are burning 30, 35 or 40 lbs. you force that up to 45 or 50 lbs., how does the relation between the CO, the CO^2 and the free oxygen change?

Mr. Isherwood: I think I can answer the question in part—that is, the relation of the different gases of combustion depends altogether on the thickness of the bed of coal upon the grate surface. If the thickness of the bed of coal does not exceed 12 in. in one direction and 6 in. in the other, it will be found that there is practically a perfect combustion with coal of the ordinary lump size, and that just twice the quantity of oxygen or atmospheric air has been supplied that is chemically required. If you will simply increase the depth of the coal on the grate bars you can have any proportion between carbonic acid, carbonic oxide, unconsumed air and free oxygen that you like. If you will make sufficient grate you will get the ordinary gasogen, in which nearly the whole of the carbon of the coal is converted into carbonic oxide. The temperature of combustion is entirely independent of its rapidity. The temperature of all fires at the surface of the coal is exactly the same, and you will have perfect combustion if you will keep within those limits of thickness. Good firing consists in knowing what those limits are and keeping within them. Some particular fireman or some particular watch of firemen do a great deal better than others. They carry the same steam with very much less fuel, and if you watch them you will find the reason very plainly. They have found out by practice the exact thickness of the bed of coal that gives them the maximum result, and they adhere to that. Other firemen, less observing, do not know that and violate the rule, and, of course,

make a great deal of carbonic oxide and lose a great deal of the economic effect. But the whole question is simply one of thickness of coal on the grate-bars. By varying that you can obtain just any ratio of those gases among themselves that you desire.

MR. MCBRIDE: I happen to have in my pocket the analysis of the gases of some boilers that I am running. I find that the amount of carbonic acid gas, carbonic oxide and oxygen can be varied to almost any extent you want by increasing or decreasing the amount of air admitted to the ash-pit: CO^2, 15.6; oxygen, 3.3; CO, one-tenth of one per cent.; carbonic acid, 17; one-half of one per cent. of oxygen and 5.1 of carbonic oxide. Now, in that particular case I did not have oxygen enough admitted to the ash pit, so I gave it more, and I immediately brought down the carbonic oxide to one-tenth of one per cent. This is burning a by-product which we have—logwood chips. It is nearly 50 per cent. water. Here is one of coal: Carbonic acid, 11.48; oxygen, 2.7; carbonic oxide, 1.6.

I use the Elliott gas-testing apparatus, and I make analyses of the gases every few days. I find, when the boilers are not making steam as they ought, by an analysis of the gases, a large amount of carbonic oxide going to loss and not sufficient oxygen. I can regulate it very nicely by increasing or decreasing the amount of fuel burned and by regulating the air.

MR. FORNEY: I will inquire if any one present has any data with reference to the water capacity of water-tube boilers in proportion to the quantity of fuel consumed. It has seemed to me from the general drift of the papers on this subject that some difficulty in the operation of water-tube boilers was experienced from the fact that the water capacity of the boiler was so extremely small in proportion to the old-fashioned shell boiler, and that naturally led me backward to the experience in locomotives, which, as you know, years ago were of small dimensions, and as traffic and business increased the demands upon the locomotives increased in somewhat like proportions, but the size of the boilers unfortunately did not. Now I think it has been proved a great many times in locomotive practice that the increased water capacity is a decided advantage in the operation of the locomotive and the boiler. I may relate a little experience which has already been in print, but which may be new to most of you, that I had some years ago with some engines built for a Western railroad, and which had what we called straight-top boilers—that is, there was no wagon-top for steam space, and the boilers were of comparatively small diameter. Those engines were put to work, and gave considerable trouble. They would not make steam, and they did not do their duty properly. Finally a trial was made of those engines with some others which had boilers of a larger diameter and wagon-tops of considerable height to give steam room, and they were run in competition, taking alternate trains every other day. The result was that the straight-topped boiler was very badly beaten. The method of operating was this: The large boilers, having a large water capacity and plenty of steam room, on approaching a heavy grade were pumped as full as it was possible to carry the water without working the water through the cylinders. The result was that in coming to a difficult place in the grade the engineer could shut off, or partly shut off, his water supply, and work up the hot water which was stored up in the boiler to a certain extent. This gave him a reserve power that he could fall back upon. I am aware, of course, that marine engines and boilers are not called upon to work under as many different degrees of power as locomotives; but at the same time it seems to me that a large water capacity must be a matter of considerable importance even in marine boilers, and inasmuch as the water capacity of water-tube boilers is very much less than of cylinder boilers, that it must be a matter worthy of attention. I may add that I have in my hand a letter which I have received from Mr. Hazelhurst, Superintendent of Machinery of the Baltimore & Ohio Railroad, in which he gives me the water capacity of an engine on that road. Mr. Hazelhurst says:

"It gives me pleasure to furnish you the information as to the water capacity of engine 937, which is the one that we tested on the 17-mile grade, burning some 192 lbs. of coal to the square foot of grate per hour. The results given are actual results, and are not calculated, the engine being weighed with the water at the different gauges and when full:

Capacity of Cold Water in Boiler.	Lbs.	Cub. Ft.
Full to whistle	14,400	230.93
Fourth gauge	11,100	178.01
Third gauge	10,400	166.78
Second gauge	10,050	161.17
First gauge	9,200	147.54
Steam space with three gauges of water		64.15

"The outside diameter of boiler at smallest ring is 54 in.; height of wagon-top, 8 in.; and square feet of grate surface, 28.33."

MR. ALMY: I would say in regard to the weight of water in a tubulous boiler that has been in use some three years, that the weight of water is about 1¼ lbs. per square foot of heating surface. This boiler develops 272 indicated H.P. on 3½ in. air pressure, and weighs about 5½ tons. There is trouble to maintain the water in it and carry a steady steam pressure. It runs with about 225 lbs. steam pressure, and has been run at 250 lbs. I have one boiler that I built four and one-half years ago that weighed 6,500 lbs. that had 1,400 lbs. of water. That has run about 75,000 miles, developing 140 indicated H.P., and it shows an economy over a tubular boiler of 13 per cent. in four and one-half years. In regard to the heat of the outside casing, the temperature is about 120°.

PROFESSOR HUTTON: For the credit of my old friend and colleague, Professor Trowbridge, I should like to refer, in this discussion of water-tube boilers, to a boiler which he designed and which was experimented with for some time at New Haven, and which, I think, deserved a better fate than it has received. Professor Trowbridge's coil boiler was a spiral coil, built very much upon the design of a base-burning stove. The hopper, which was intended to be a magazine feed for the boiler, came down in the middle, and this coil of pipe surrounded it. But the special feature of interest in that boiler was the forced circulation to which reference has been made. The feed pump of the boiler was not only a feed pump but a circulating pump, so that the water which was to be evaporated was kept continuously circulated in the evaporating coil, and was delivered from the top of that coil into a little bit of a steam space from which the engine took its supply. As a result of the design and that feature of forced circulation in the boiler, a little bit of a boiler, which you could cover with a flour barrel, was competent to run a 40-ft. launch, and they got a surprising amount of efficiency from it without so much reference to economy. But the quantity of steam that little machine would make was surprising. Professor Richards, of the Sheffield School, made an elaborate investigation of it. It was the aim to supply the demand for a boiler which should be practically self-managing—that would require no more attention from anybody than a base-burning stove. You filled it in the morning and you filled a magazine of water, and it was to be self-feeding and keep its level constant until somebody thought of looking at it again, with the idea that in printing-offices and other places in the country such a thing would be useful. Financial and other reasons prevented the thing from getting the opportunity that I would have been glad to see for it. But the device showed the principle of forced circulation in a coiled boiler of that type.

MR. PARSONS: The tendency of the meeting seems to be to lay stress on the earlier wearing out of the tubes in the water-tube type compared with the fire-tube type. That has not been my experience. The reason that I have given to myself I should like to state as a suggestion, as I have never seen it offered by any one in discussing the subject of water-tube boilers. While the conditions would not seem to warrant much change in the two types of boiler, the conditions are exactly reversed; the water on one side in one type, the products of combustion in the other type. We know that it is impossible to make a sheet of metal absolutely homogeneous. We know that because it does pit irregularly. If it was absolutely homogeneous, uniform in its character, there is no more reason why a pit should take place in one place than in another. But we know the metal is not homogeneous. That sheet of metal which is shown here in section is drawn into a tube the thickness of which I have exaggerated. The metal is compressed on this side and lengthened on that. If this is the fire side it meets the compressed metal. If it is the water side, the fire side meets the stretched metal, and I have attributed the earlier loss of life as due to that cause. I offer it as a suggestion. It may not be new; but I have never seen it offered before, and if I am wrong I would like to be corrected. The fire tube lasts longer apparently than the water tube, and the condition is reversed. The elongated metal in one case is next to the products of combustion and subject to the deleterious action of the gases; while if the gases pass through the tube they are acting on the compressed side. If the metal is pulled apart, and if it is granular or fibrous, the gases would have more of a chance to enter in and start the action. We all know that corrosion, once started, continues very rapidly.

MR. HENNING: I think this effect is explained much more readily on another theory. If we take a fire tube, the ashes and sulphurous acids that are formed by the moisture in these ashes deposited by the fires, or the lye alkalines that are formed, will corrode the fire tube inside. If it is a water tube, the water is inside and the fire outside and the tension side of the

metal will corrode before the other. I think that is the reason of it. I do not think that the hot-formed tube has any compression or tension on either side of the metal, because the annealing effect of the slowly cooling tube will make the material perfectly uniform on both sides.

MR. SEWELL: I would like to ask if it is well known that tubes will last longer as fire tubes than as water tubes. I saw a tube some time ago that had been in use, say 15 years, running nearly 24 hours a day. It was taken out, and you could hardly tell that the tube had been used. There appeared to be no detrimental action taken whatever. Is it absolutely known to be a fact that the statement that is made is true?

MR. FORNEY: The statement that has been made this evening is a very interesting one with reference to the reasons why water tubes corrode more rapidly than fire tubes. It has been proposed quite a number of years ago that metal under a state of tension, if exposed to any corrosive influences, would corrode much more rapidly than if it was not in a state of tension Now this shows, I think, from the way in which boilers will corrode along the caulking edge just at the point at which the tension on the metal is greatest. I remember some years ago I made an experiment by getting some rubber plates or rubber sheets which were about the thickness of boiler plates, and fastening them together precisely in the same way as boiler plates are fastened, and then subjecting them to tension. Before doing this I drew a couple of lines across the edge of the rubber, so that I could see the way in which they stretched. That, for instance (referring to a sketch), is supposed to be a section of a plate. I used a bolt instead of a rivet in this case, and held them together in that way. Now, before subjecting them to tension, I drew two fine lines across there, parallel lines, right at this point, and then stretched the rubber so as to draw them apart. When it was stretched, the lines assumed this shape. They were curved in that way, showing that the rubber at that point was subjected to a greater amount of tension than at any other point, and that it was not stretched uniformly. That action no doubt takes place in a lap joint where the plates are subjected to that tension, and, as you know, the corrosion takes place right at that point.

There is another fact that throws a little light on that, and that is the corrosion of steam chests. In locomotives, when they formerly used tallow for lubrication, which had a corrosive matter in it, the steam chests would corrode around in the corners. It would eat away into the corner of the steam chest. You are all familiar with the rapidity with which boiler stays will sometimes corrode. I think the reason for that very often is that they are under a state of great tension, and in that condition corrosion takes place much more rapidly than otherwise. The experiment would not be a difficult one to make to subject wire or other pieces of metal to tension and expose them to some corrosive fluid, and it would be very interesting in this connection.

PROFESSOR HUTTON: This affords a very good example of how possible it is to look at the same thing from different standpoints. I think that there is quite a different explanation of that phenomenon. There (referring to the sketch) is the boiler plate with tension on this side and tension on that. The tendency, therefore, of these two sheets is to produce just that effect before the thing would break. What would happen would be that there is formed naturally from the water a scale of sesquioxide of iron, and that surface is successively broken off and so a groove is eaten in. I do not think that the boiler being under tension is the explanation, but that the scale of iron being broken off is the explanation.

MR. FORNEY: That is only another way, it seems to me, of saying that in tension corrosion takes place more rapidly. I do not know whether it is chemical action or mechanical action.

MR. COXE: In the anthracite coal region we have had some difficulties that bear upon this subject. The practical fact is that you will find that, at a joint, either the rivets go or the boiler, but not both. There is an electrical action. That is to say, the difference in the quality of the iron, which will form a couple. I have seen boilers with every rivet eaten. You will find where there is a good supply of sulphuric acid in the feed water that you either eat your rivets off or you eat your boiler. Very seldom both. I should say, if you examined those stay bolts that Mr. Forney referred to, you would find they were chemically different. You would find they were softer or more easily acted on than the iron of the boiler.

MR. FORNEY: Before adjourning, I would like to say a word. As announced in the notice of this meeting, this is the last one of the series of meetings held for the discussion of technical subjects, and with these meetings the duties of the Committee end. Whether the meetings will be continued in the coming fall and winter or not will remain for the members of the Society to determine. The experiment has been undertaken by some of us to find out, if we could, whether such meetings as these would be successful. I think it may fairly be claimed that at least a moderate degree of interest has attended them, and that they have received a sufficient amount of encouragement to continue them hereafter. When they were first started there were members of the Association who exercised a considerable amount of ingenuity in finding reasons to show why such meetings could not succeed; whether those reasons were well grounded or not the past experience will have to be the answer. Some opposition was also made to holding such meetings from the fact that it was thought that the non-resident members would complain that the resident members had advantages in these meetings which those who live out of town had not, and that that might result in some feeling of jealousy, and the precedent was cited that in the Society of Civil Engineers some difficulty of that kind had been found and considerable feeling had grown up. It seems to me that it is hardly fair to attribute such a feeling as that to the non resident members. I can hardly believe that any such dog-in-the-manger feeling can have any considerable existence in the membership outside New York. At any rate, there can be no sound reason why half-a-dozen members of the Society, or a dozen or a hundred members, may not meet together in this room for the discussion of subjects which are mutually interesting. The same thing is true of the people who live elsewhere. The members in Boston have that same privilege. The members in Chicago can do the same thing. I may relate a little experience I had in the Master Car Builders' Association, which has had an existence of some 20 or 25 years, and probably some 15 years ago a local Society was organized in this city which was really an offshoot of the parent Association. The meetings of the local Society have been held now, I think, for 15 years. Since then similar organizations have been formed in Boston, in Buffalo and in Chicago, and instead of their detracting from the interest or the value of the proceedings of the parent Association, which holds its meetings only once a year, I think it was universally acknowledged that the local meetings had helped to increase the interest in the parent Association; that it results in preliminary discussions of subjects which come up before the annual meetings, and that men come to them with a supply of information on the subjects which are to be considered which they would not otherwise have It is not plain to me why these same results would not occur in the Mechanical Engineers' Society. If meetings of this kind could be established in Boston and other cities wherever there was a sufficient number to form a local assemblage, the result would be that the members would have a greater interest in the Association in New York than they would have if such meetings are not held. I therefore think that these meetings should be continued and that some permanent committee should be established to take charge of them.

MR. MCBRIDE: I think it would be a proper thing to adopt a vote of thanks to the Committee for arranging these meetings this winter from which we have all derived great profit.

Such a motion was carried.

DR. EMERY: To avoid the necessity of a meeting for the purposes of organization next year, I make the suggestion that the Committee be continued with power.

MR. FORNEY: I do not think that would be judicious. In the first place, I do not mean to be on that committee another year; and, in the next place, the subject will come up before the annual meeting of the Association for full and complete discussion, and therefore arrangements for next year's meetings should be deferred until it is known what action the Society itself will take.

ELECTRIC SIGNALING WITHOUT WIRES.

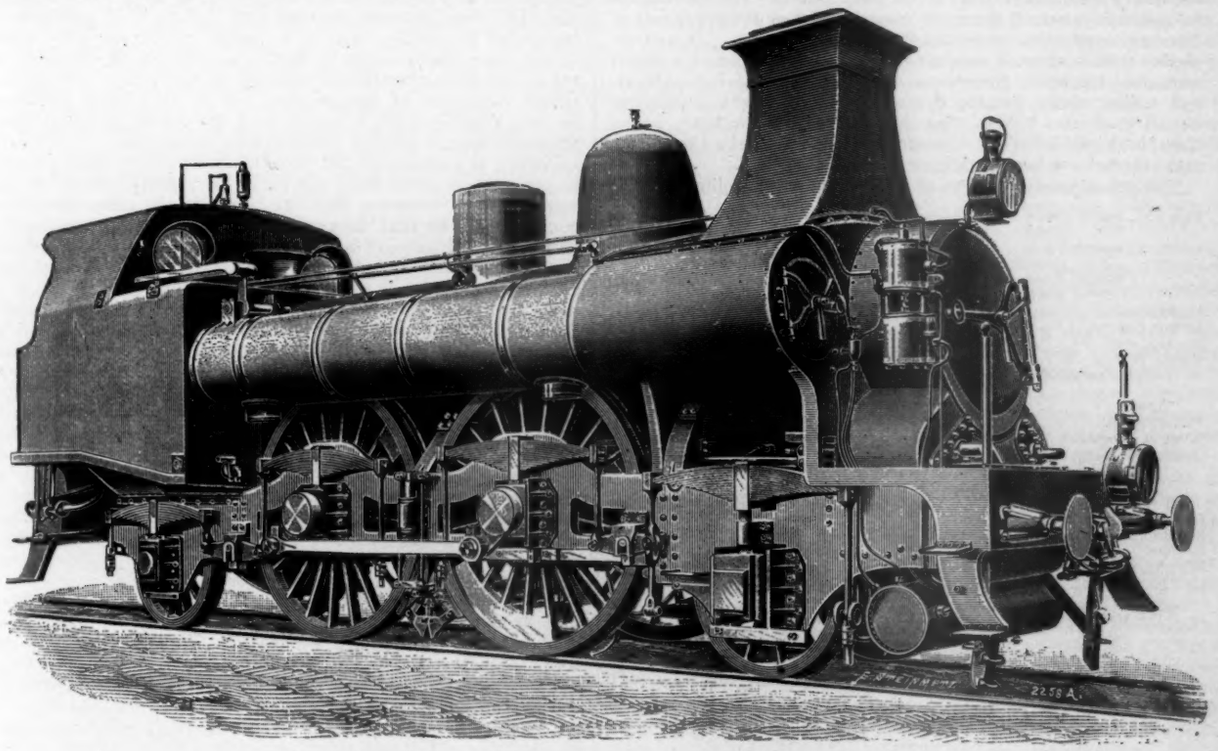
IN a paper on "Electric Signaling without Wires," read before the Society of Arts recently, Mr. W. H. Preece, F.R.S., considered the subject of sending signals by means of electricity from one place to another without the intervention of any conductor, unless the all-pervading ether be termed a conductor. In 1884 it was noticed that messages sent through insulated wires buried underground in the Gray's Inn Road were read upon telephone circuits carried on the tops of the houses 80 ft. away. In 1885 it was found that currents passing in a telegraph line between Durham and Darlington produced effects in a parallel line 10¼ miles distant. These results were

not conclusive, because it could not be proved that they were not due to accidental connections through the network of wires between those two places. In short, it was doubtful whether they were the result of induction or of conduction. But in 1886 experiments were made on parallel lines 4½ miles apart between Bristol and Gloucester, where there were no intermediate conductors to vitiate the results. Moreover, the circuits used were metallic throughout. Under these circumstances only weak disturbances were detected, though when the experiments were repeated in 1889 in the light of experience more success was obtained. The theoretical possibility of signaling without wires was thus shown, and in 1892 a practical test was made in the Bristol Channel. On Lavernock Point, near Cardiff, a copper wire 1,267 yds. long was hung on poles, the circuit being completed by earth. On the sands at low-water mark, 600 yds. from this circuit, and parallel to it, two covered copper wires and one bare one were laid down, their ends being buried deep in the sand. On Flat Holm Island, 3.1 miles away, another covered wire 600 yds. long was laid down. On the shore an alternating current (which was controlled by a Morse key) with a frequency of 192, a voltage of 150, and of any desirable strength up to 15 ampères was sent through the primary circuit. The signals received on Flat Holm on the secondary circuit produced sound and were read on a pair of telephones. By this means messages were successfully sent. The same method was tried with another island, Steep Holm, 5.35 miles away, but was scarcely successful. Disturbances were indeed perceptible, but the signals could not be read. Such experiments, in which careful precautions were taken to eliminate the effects of earth-currents, proved the possibility of signaling between England and France without any wires being carried across the Channel. But the expense would not be negligible, for at Lavernock Point a 2-H.P. engine was required to get results over 3 or 4 miles. Mr. Preece also described experiments made with parallel wires about 1¼ mile apart stretched on poles along the banks of the Caledonian Canal, near Inverness. Here, with the use of ordinary telegraphic apparatus, Morse signaling was easy and speaking by telephone possible. Mr. Preece's critics contend that his results are due to conduction through the earth. He himself maintains they are due to electro-magnetic induction. The rapidly alternating current in the primary circuit throws the surrounding ether into oscillations, and energy is radiated in electric waves. These waves spread out, as do waves of light, and, if they fall on conductors properly placed and sympathetically prepared, are reconverted into an alternate current in the secondary circuit.

TRIPLE-BOILER LOCOMOTIVE FOR THE BELGIAN STATE RAILWAY.

THE curious-looking locomotive which we illustrate herewith was built in 1888 by the Société St. Leonard, of Liège, Belgium, to compete with another engine designed by the Cockerill Company, of Seraing, and exhibited by them at the Paris Exhibition of 1889. This latter, now classed as "Type 12," is less powerful than the triple boiler engine, but was nevertheless, after numerous trials, finally adopted by the Chemin de Fer de l'Etat as their standard express engine, of which over sixty have since been built by the various well-known Belgian firms, including the St. Leonard Company. At that date the old "Type 1," with four coupled drivers, single leaders, Belpaire fire-box, and large dome placed directly behind the chimney, was proving insufficient for the increasing weight of the trains, particularly with the heavy international cars and the spacious ordinary six-wheeled carriages—trains which compared rather with German than with French rolling stock as regards both weight and accommodation.

In calling for competitive designs of new engines, the authorities required that the competing locomotives should be able to haul a gross load of 150 tons up a gradient of 1 in 200



TRIPLE BOILER LOCOMOTIVE FOR THE BELGIAN STATE RAILWAY.

at 56 miles per hour, without diminution of steam pressure or of the level of the water in the boiler, for a distance of three miles at least. Both engines referred to above proved very satisfactory, and attained speeds of 59 miles per hour under the conditions named. Indeed, the triple-boiler engine ran up the grade stated at 61 miles per hour, and took trains of 150 tons gross (that is, including engines) up inclines of 1 in 62 at 40 miles per hour, and, on other occasions, loads of 182 tons up the same gradient at 31 miles per hour. From these results, obtained under similar conditions, the powers developed by the two engines were found to be 1,235 H.P. for the triple-boiler locomotive, and 1,189 H.P. by the "Type 12." At 59.4 miles per hour, with 150 tons, on a grade of 1 in 200, the power of the triple-boiler engine exerted 1,339 H.P.

The two engines in question differed mainly in their boilers, as they had the same cylinder capacities. As will be seen from our engravings, the engine illustrated has a boiler with three barrels, which have the same fire-box tube-plate, and the same extension smoke-box in common. The chimney is square, spreading out at its base to embrace the side divisions of the smoke-box, an arrangement which should improve the draught in the side flues, although it may be doubted if the exhaust steam acts so efficiently in a square chimney as in a round one, and it is certain that it obstructs the view somewhat. The

smoke and steam also are said to be thrown less clear away from the engine than with the round forms. The grate area is double that of any French express engines and superior to that of "Type 12," and the heating surface is 50 per cent. more than in the "Type 12" and 10 square meters (107 sq. ft.) above that obtained in Flaman's double-boiler locomotive.

The coal consumption is given as 254 to 322 kilogrammes per hour per square meter of grate surface; in other words, it burns an average of 3,167 lbs. per hour, which, taking the commercial speed as 44 miles per hour, corresponds to 72 lbs. per mile; 1 lb. of coal is said to evaporate 5.6 lbs. of water upon the average, or 6.6 lbs. as a maximum, results no better than obtained with American locomotives; but the coal burned by these Belgian locomotives is of the poorest "slack," unmixed with briquettes, as commonly practiced in France. As regards economy, the results given by the engine are said to be excellent. There are, it is true, certain details of construction that could be improved even in the existing engine, as, for example, the square chimney and the absence of running-boards permitting the engine to be got at when under way. There is also sometimes an unequal expansion of the tube-plate, due to a superior draft in the central series of tubes. A trouble also with engines of abnormally large grate area is the difficulty of obtaining a sufficient draft in the smoke-box. The locomotive in question is one of the most unconventional developments of locomotive practice since the time of Stephenson. It was designed with a view of obtaining great steaming power without mounting the boiler dangerously high. Continental and American trains make greater demands on the steam-producing capacity of the boilers than is the case in England, hence these multiple boilers of Flaman, the St. Leonard's Company, and others have been produced.

The principal dimensions of the engine are as follows:

Fire-box, width inside	9′ 3″
" " outside	9′ 10″
" length inside	5′ 10″
" " outside	6′ 3″
" height, front	3′ 7″
" " back	2′ 9″
Grate area	56 sq. ft.
Boiler, central	4′ 3″ in diam.
Boilers, side	2′ 3″ "
Tubes, central	180
" side series (48 each)	96
Total	276
Tubes, length	15′
Working pressure	180 lbs. per sq.in.
Heating surface, fire-box	121.6 sq. ft.
" " boilers	1931.0 "
Total	2052.6 sq. ft.
Cylinders, diameter	19.6″
Stroke	23.5″
Drivers	6′ 10½″ in diam.
Weight, engine	56.8 tons.
" tender	29.5 "
Total	86.3 tons.

—*Engineering.*

THE YARROW BOILER.

APROPOS of the discussion before the meeting of the Mechanical Engineers, which is printed in another column, we would call attention to the Yarrow boiler, a description of which was published in our issue for March, 1891, and which is now being exploited in this country by Mr. Horace See, of No. 1 Broadway, New York. Inasmuch as the engravings published in our former issue gave a complete description of the construction of the boiler, it is not necessary to recapitulate the whole at the present time. It consists of three parallel longitudinal chambers, two of which are of the form of the sector of a circle, while the third and upper is a complete circle. The three chambers are located at the angles of a nearly equilateral triangle with the grate between the lower two, while straight tubes connect the lower and the upper ones. The engraving which we publish in this connection is taken from a photograph of a boiler which has recently been built by Mr. Yarrow in England. Boilers of this type were used on the torpedo boat *Hornet*, a description of whose trial appears in another column of this issue.

In a recent discussion before the Institution of Naval Architects in England, Mr. Yarrow stated that it was about seven years ago that his firm first commenced adopting straight tubes in their water-tube boilers, having been previously led away by what he believed to be the popular fallacy that curved tubes were necessary in order to allow for contraction and expansion. No doubt it was necessary to curve the tubes in some designs, but it did not follow that it was necessary in all.

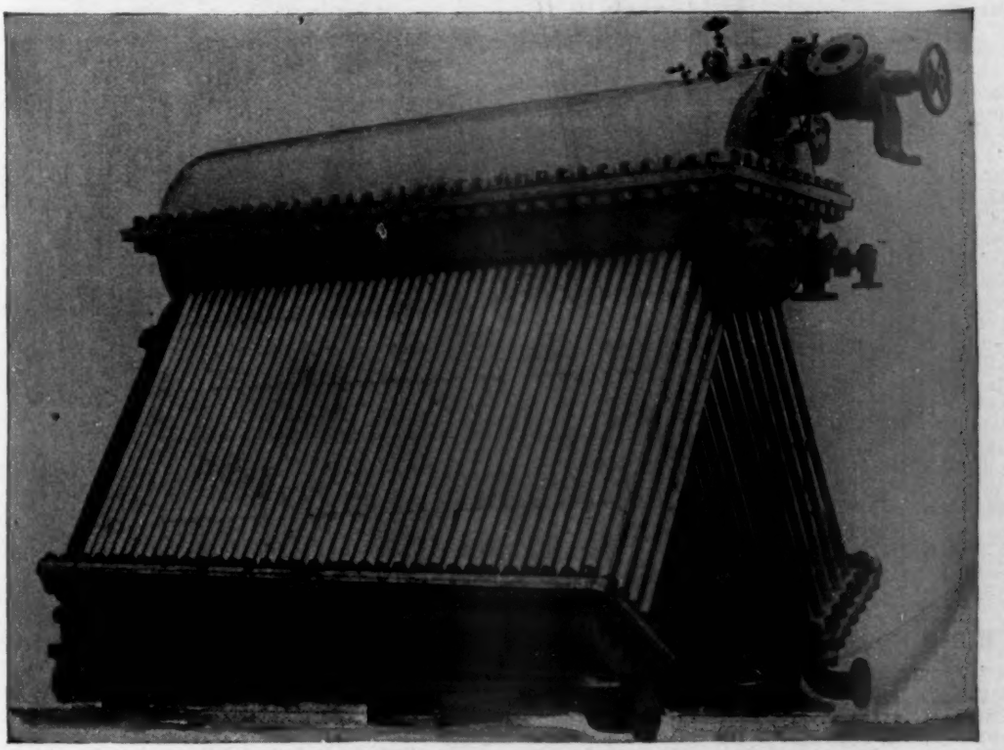
Although his firm had built a large number of water-tube boilers during the last seven years with straight tubes, it might be of interest to the meeting to know that they had never had a single leakage between the tube and tube-plate. This fact proved, they believed, that there was nothing objectionable in the straight tube system, while it clearly offered many advantages, both in construction and in service. Experience had shown that steel tubes, whether galvanized or not, rapidly deteriorated, and if the tubes were galvanized on the inside a rough surface was caused, which, in some instances, retarded the circulation of the water. There was also the possibility of portions of spelter lodging in the tubes and partially blocking up the passage, or causing such an obstruction which would allow sediment to collect. So far as his experience went, it led to the conclusion that copper tubes were more durable than steel, but in the use of copper it was essential that it should be very pure, and that the tube, under all circumstances, should be below the level of the water and always filled, otherwise the copper might become overheated.

He also stated that his firm commenced experiments with water-tube boilers as far back as 1877, and put a water-tube boiler in a torpedo boat in the year 1889, and their experience indicated that very small changes in design materially affect the action of a boiler; small alterations in some cases making the difference between success and failure. If portions of the boiler be rigidly secured by stays, which are not subject to the same temperature as the tubes, serious strains may be set up involving continual bending of the tubes to meet continual variations of temperature. If in such cases the tubes be only slightly bent, it might lead to trouble, as small alterations in length involve considerable alterations in the curve necessary to conform to the variation in length. Consequently in cases where portions of the boiler are rigidly secured to one another, it is necessary that the bends in the tubes should be considerable, so that they can easily, and without excessive strain, suit differences of temperature. The practice of his firm was to aim at allowing tubes freedom to expand and contract; and, as the contraction and expansion of a group of tubes had been found to be nearly uniform under the conditions of working, any small difference of length seemed to be met by the elasticity of the material. Mr. Yarrow, and those who worked with him, felt satisfied on this point, having made very careful experiments to test it, and he thought it would be admitted that it was most desirable—in fact, almost essential—that access be freely obtained to the interior of the tubes, for the purpose of examination and for cleaning. For these reasons he was strongly in favor of straight tubes, which at the same time reduced the cost of construction, and was a convenience in actual working on account of the ease in supplying spare tubes. In this way there was avoided the large variety of forms of spare tubes necessary with boilers where the tubes were curved to different forms.

It was often asked, Mr. Yarrow continued, how, in boilers such as those in H. M. S. *Hornet* and other previous vessels, they managed to replace the tubes. The form of boilers adopted in the *Hornet*, to which the speaker was referring, was not of the type described in Mr. Milton's paper just read, and, as throwing some light on the subject, it might interest the meeting to know that on one of the trials with this vessel (in the boilers of which there are over 8,000 tubes) one of the tubes gave way on account of faulty manufacture, and the time occupied in taking out and replacing this tube ready for expanding was only 40 minutes. His firm were also led away in their first boilers with the idea that down pipes were necessary to insure circulation, and in all the boilers made by them up to three years ago they provided four down pipes, two at each end; these down pipes being suitably curved to allow for variations in lengths between the upper and lower portions of the boiler. For purposes of experiment they removed two of the down pipes, and found the action of the boiler unaffected. They then ultimately dispensed with the other two, with the same result, thereby saving both weight and length and obtaining greater simplicity. Mr. Yarrow maintained that those who had had both water-tube boilers of a satisfactory type under their management, and those of the locomotive type, would be ready to admit that it required less skill to stoke a water-tube boiler than a locomotive boiler, as with the latter it was necessary to keep the grate uniformly covered with fuel for fear of admitting cold air, while with the former such care was unnecessary. In order to test the effect of sudden changes of temperature on one of his firm's water-tube boilers, they had, when experimenting with it in the yard, forced it excessively, and had then suddenly pulled out the fire and stripped the boiler of its casings, so as to cool it as quickly as possible. They then replaced the casings, lit up as rapidly as possible, raising steam to 180 lbs. The result of this somewhat severe treatment showed that there was not the

slightest alteration in form or any injury to the boiler. The results obtained with one of the boilers of H. M. S. *Hornet*, Mr. Yarrow thought, would, perhaps, interest the meeting. It weighed complete, with fittings, smoke-box, fire-doors, fire-bricks, funnel, casings, and all boiler mountings, also including water up to working level, 5 tons 7 cwt. On carefully conducted experiments in the yard it was found that 12,500 lbs. of water were evaporated per hour from 60° F. to 180 lbs. pressure. In order to compare the relative efficiency of water-tube boilers with locomotive boilers, there were the following facts: In H. M. S. *Havock* his firm had placed two locomotive boilers, and the machinery indicated on trial about 3,500 H.P., with an air pressure of 3 in. In the *Hornet*, a sister ship, provided with similar engines and fitted with eight water-tube boilers, as previously mentioned, they obtained, with a very low air pressure averaging 1¼ in., 4,300 H P. The eight boilers in the *Hornet* weighed 11 tons less than the locomotive boilers in the *Havock*.

They had every reason to fear, from what they had been told, that trouble would be experienced in working a group of small rapidly evaporating boilers in the *Hornet*, but, as a matter of fact, they had experienced no difficulty whatever, the feed being arranged in, as it were, two stages. The feed-pumps on the engines take their suction from the hot-well, and deliver into a reservoir at 50 lbs. pressure, and from this reservoir the donkeys take their suction, each boiler being provided with an independent donkey. By this means a very ample supply of water was always insured on the suction side of the donkeys, and the pipes leading to them could be of moderate dimensions, in consequence of the 50 lbs. pressure delivering the water readily to the suction side of the pumps. To insure the reservoir always being well filled, there was a small amount of auxiliary feed constantly passing into it, the surplus, beyond that which was necessary for the supply of the boilers, being returned to the tank through a relief valve loaded to 50 lbs. As was well known, his firm had been strong advocates for the locomotive type of boiler, especially as the form they had adopted was found to work satisfactorily and to be durable; but the recent success with water-tube boilers obliged them to advance with the times and to modify their opinion, a course more particularly necessary in view of the possible further rise of working pressures in the immediate future. The recent action of the Admiralty in, as it was, forcing on numerous contractors the adoption of water-tube boilers had frequently been unfavorably criticised, but Mr. Yarrow believed that time would prove that the greatest possible credit was due to the authorities for having thus taken the initiative in the introduction in this country of a form of boiler which there was little doubt is destined to replace old types. He was fully convinced that, in spite of those failures which were naturally to be expected to accompany such a sudden change of practice, naval architects and engineers would, in a few years, recognize in the action of the British Admiralty a wise and important step in the advance of marine engineering, and he believed before very long that it would be generally admitted, not only in this country, but throughout the world, that the greatest credit was due to the authorities at Whitehall for having had the boldness to act as they had done.



THE YARROW BOILER.

LOCOMOTIVE VALVE-GEAR WITH SEPARATE ADMISSION AND EXHAUST-VALVES.

By E. Polonceau.

The Paris & Orleans Railway Company have from time to time tried to get more economical results from their locomotives than is possible when using the ordinary slide-valve for both admission and exhaust. In 1858 a Meyer expansion valve-gear was tried, but the results were not satisfactory; the increased economy obtained being more than counterbalanced by the extra friction of the valves and the extra complication of the mechanism. In 1878 a compound locomotive was tried, but again the results were unsatisfactory. It is to be remarked that compounding involves a more or less complete transformation of the locomotive, and that consequently on account of expense it cannot be applied to all the engines already existing. It appears, therefore, to be simpler to try to get increased economy by a change which will only involve replacing the cylinders and part of the valve-gear. These considerations led the Company to try the system described below, recommended by Messrs. Durant and Lencauchez.

The immediate aim of the experiments was to prolong the expansion and to suitably control the compression while still using a link-motion gear. In the first trial made, on engine No. 67, the admission slide-valve was driven by a Gooch link-motion, and had certain peculiarities of construction, the object being to double the area of opening and to partially relieve the pressure on the face. The exhaust slide-valve, placed at the lower side of the cylinder, received its motion from the cross-head. Exhaust began when the piston had still 22 per cent. of its stroke to perform, and compression began when it had done 22 per cent. of the return stroke. At low speeds the results were satisfactory, but at high speeds the great amount of compression was objectionable.

In the second trial another locomotive, No. 76, had two exhaust-valves of the Corliss type driven from the cross-head, and the cylinders were larger. Here, again, the compression was too great for high speeds.

In the next arrangement tried the rods driving the admission and exhaust-valves worked in the same link, and were connected to each other, so that they were displaced simultaneously; the same engines on which the above experiments were made being used, cylinders and valves being unaltered. In engine No. 67 release took place when 25 per cent. of the piston-stroke remained to be done, and compression began

when 30 per cent. of the return stroke had been done. The results were entirely satisfactory, reversing being easily performed, and a greater amount of work for the same weight of steam being obtained than with ordinary locomotives.

As a result of the preceding experiments, new cylinders with four Corliss valves and the smallest possible clearance spaces were fitted to engine No. 67, and this design has been applied to all new passenger engines for the last year and a half. The advantages of this arrangement are as follows:

1. The conditions relating to cooling of the steam on entering the cylinder are better than in the ordinary engines, since the sides of the admission-ports are not cooled by the escape of the exhaust steam.

2. The fall of pressure is less, since the port area is nearly double.

3. The diminution of the clearance volume, prolongation of the expansion, lessening of the compression are all favorable to the more efficient use of the steam in the cylinder.

4. The back pressure is lessened by the diminution of the clearance volume, since the quantity of exhaust steam to be got rid of is reduced.

5. The friction of the four Corliss valves is less than that of an ordinary slide-valve.

6. The arrangement of the exhaust-valves at the lower side of the cylinder allows a natural drainage to take place, and drain-cocks are therefore unnecessary.

The design has been applied to eight express engines, and is being applied to three express and three goods engines in course of construction. One of these engines coming into the shops for overhaul after running 40,200 miles, the valves and valve-gear were examined. The wear of the valves and the joints of the link-motion was practically *nil*. With ordinary locomotives the valves and faces usually require adjustment after running about 15,000 miles. The consumption of fuel is 15.2 per cent. less than the average in the ordinary engines doing the same work. The expenditure of lubricant is a little higher, being 51 as against 42 grams per kilometer. —*Annales des Mines.*

WEBB'S ACADEMY AND HOME FOR SHIPBUILDERS.

ACADEMY AND HOME FOR SHIPBUILDERS.

On Saturday, May 5, the new building which has just been completed through the munificence of Mr. William H. Webb, the distinguished shipbuilder, was dedicated to the uses for which it is intended. These are indicated by its name, which is "Webb's Academy and Home." Its purpose is to establish a sort of refuge or home for poor men who have worked on the hulls or engines of ships; and, second, a school of naval construction for boys who are unable to secure the advantages of such an education elsewhere. Mr. Webb has devoted $2,000,000 to establishing this home and school.

The building is located at Fordham Heights, facing on Sedgewick Avenue, overlooking the Hudson and Harlem rivers. Thirteen acres of ground were bought for this purpose, and the magnificent building is a striking feature in this picturesque region. As will be seen from the illustration—for which we are indebted to *Seaboard*—the main structure is of the Romanesque order of architecture, of plain stone, and round arches on the upper tier of windows. It provides the most complete facilities for the purpose for which it is intended that the broadest liberality could supply. Not only is it intended that when misfortune has overtaken men whose wives are dependent upon them, that they shall not be separated, and that they may descend the decline of life, hand in hand, if they are disposed to do so. With this in view, provision has been made so that poor men and their wives will both be cared for. The school, it is said, will be on a par with the leading educational institutions of the world for teaching the most advanced methods of marine construction.

The dedicatory exercises were led by Bishop Henry C. Potter, of the New York Diocese.

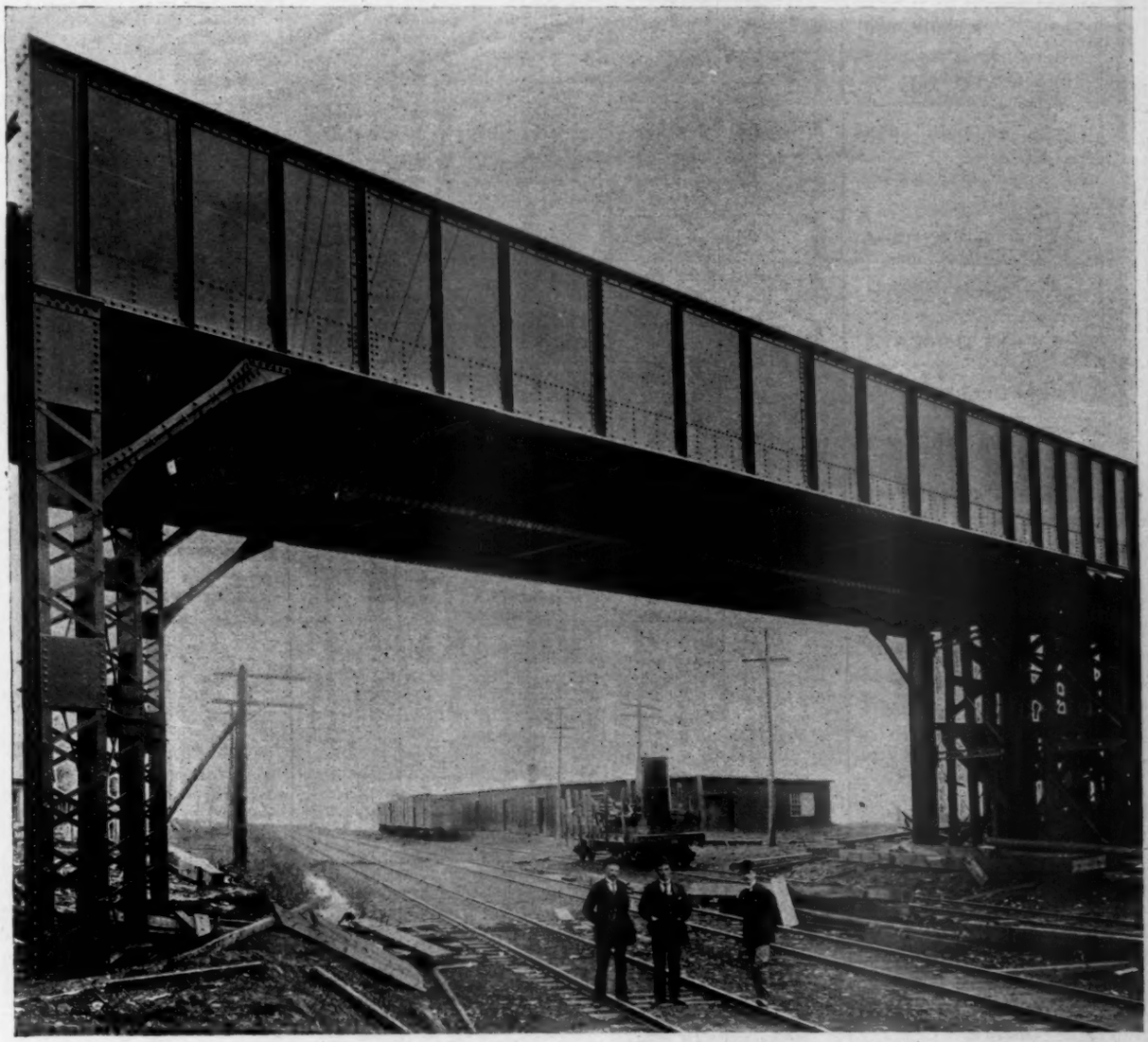
The institution has been incorporated, and the trustees are W. H. Webb, President; Stevenson Taylor, Secretary; Thomas F. Rowland, Treasurer; Professor Frederick R. Hutton, Columbia College; Andrew Reed, Resident Trustee; Albert G. Bogert, Charles S. Smith, Merritt Trimble, T. S. Marvel, Newburgh, and Charles H. Cramp, Philadelphia.

It is magnificent benefactions like this which renew one's hope in the future of our people, which is now often sorely shaken by the ignorance, imbecility, and corruption in high places.

BRIDGE ON DULUTH, MISSABE & NORTHERN RAILWAY.

The building of the Duluth, Missabe & Northern Railway, from the junction with the Duluth & Winnipeg Railroad into Duluth, Minn., necessitated the construction of extensive dock facilities on St. Louis Bay. To reach the dock a viaduct about 2,500 ft. long and double track was constructed across the flats. The work was laid out by Mr. C. H. Martz, Chief Engineer for the Railroad Company, and the contract awarded to the Youngstown Bridge Company, of Youngstown, O., for the construction of the viaduct, according to their own designs, to be built of soft steel not reamed. The crossing of the streets necessitated the use of six or eight spans without longitudinal bracing. These spans, together with the one across the St. Paul & Duluth Railroad tracks, varied from 44 ft. to 86 ft. in length. The one which we illustrate is the span across the tracks of the St. Paul & Duluth Railroad. The extreme length is 86 ft., with a skew of 61° 30'. The span is double track, through on shelf. The live load used consisted of two 101-ton consolidation locomotives. The center girder weighed when completed 33 tons, and, as was true of

all the work in this structure, the flange angles and flange plates were all in one piece without splice. The bracing between the girders consisted of adjustable lateral rods and deep lattice struts, with gussets running to the top flange of the girders, each gusset being stiffened on the edge by two angles. The girders rest on steel columns, which are braced to the girders by knee braces, as shown in the cut. The columns are calculated to take up the bending strains due to traction and temperature. The transverse sway bracing was of adjustable rods, owing to the fact that the foundations rest on piling, thus precluding the possibility of using stiff sway bracing, as a number of structures that have been built with stiff bracing, when the foundations were on piles, have been found, in other parts of the country, to settle and render the stiff sway bracing of little service. Any slight settlement in the foundations can be accounted for by the adjustable laterals. The other spans in the viaduct were built of the same general design as this, except they were all deck, with stiff lateral bracing and frames. Besides the viaduct proper, the Youngstown Bridge Company constructed for the road two girder spans in the dock proper, and a 72-ft. girder span on columns on the line of the road. The Duluth, Missabe & Northern Railway, by means of this improvement, are enabled to haul the ore from the renowned Missabe Range to St. Louis Bay over their own tracks the entire distance, and have facilities for handling ore second to no road in the United States.



BRIDGE ON DULUTH, MISSABE & NORTHERN RAILWAY, BUILT BY THE YOUNGSTOWN BRIDGE COMPANY.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

THE object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in April, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN APRIL.

Pittsburgh, Pa., April 5.—F. J. Suter, a fireman on the Pennsylvania Railroad, was killed yesterday afternoon in the Twenty-eighth Street yards while working with the air-brakes

LOCOMOTIVE RETURNS FOR THE MONTH OF FEBRUARY, 1894.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Av. Train. Passenger Cars.	Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Cost per Car Mile. Passenger.	Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	....	....	.....	.... ..	.. ....	.....	.....	....	....	....	....	....	....	....	...	...	....	....	....	....	....	....	. ..	...	....
Canadian Pacific	602	....	443,168	586,078	266,709	1,295,955	2,152	....	....	....	....	....	82.51	....	...	5.15	12.69	0.37	....	5.82	1.46	25.49	....	....	3.07
Chic., Burlington & Quincy	542	....	.....	.....	.....	1,305,691	2,409	4.72	18.40	....	....	....	92.68	....	.	4.15	6.51	0.20	0.34	6.81	0.06	18.07	....	....	1.40
Chic., Milwaukee & St. Paul	855	....	.....	.....	.....	2,368,455	2,770	....	...	....	....	....	80.74	....	....	4.14	8.24	0.28	...	6.89	...	19.55	....	....	2.43
Chic., Rock Island & Pacific	564	....	439,842	729,710	360,563	1,530,115	2,712	....	.. .	61.70	85.43	49.26	71.71	....	....	3.18	7.28	0.25	....	6.28	0.43	17.42	....	....	2.18
Chicago & Northwestern	1010	....	724,235	1,247,306	519,159	2,490,700	2,466	....	...	....	....	....	96.66	.. .	....	3.72	8.84	0.30	....	6.29	0.89	20.04	....	....	1.81
Cincinnati Southern	....	....	.....	.....	.....	.....	.....	....	....	....	....	....	....	....	....	..	....	....	...	....	....	....	...	....	....
Cumberland & Penn.*	23	23	5,458	21,227	.....	26,685	1,147	....	....	....	....	....	83.58	....	...	9.69	4.41	0.31	....	....	2.33	16.74	...	....	....
Delaware, Lackawanna & W. Main L.	212	171	65,825	182,940	276,599	525,364	3,072	....	....	.. .	...	....	92.80	....	....	2.53	7.31	0.42	....	6.55	....	16.81	....	....	1.60
Morris & Essex Division	162	....	164,798	138,780	76,242	379,820	2,044	....	....	....	....	....	71.02	....	....	3.11	11.08	0.32	...	7.06	....	21.57	...	....	3.09
Hannibal & St. Joseph	65	65	59,613	137,318	34,961	231,892	3,567	4.66	16.21	....	....	....	90.90	16.18	7.34	2.81	6.14	0.10	0.33	6.76	0.03	16.17	....	....	1.39
Kansas City, Ft. S. & Memphis	148	....	85,440	197,501	87,475	370,416	2,503	....	....	....	....	....	77.22	....	....	2.93	5.83	0.19	0.45	7.39	...	16.79	....	....	1.48
Kan. City, Mem. & Birm	41	38	32,894	52,511	11,349	96,754	2,546	....	....	..	....	....	73.53	....	....	3.84	4.09	0.26	0.33	6.99	....	15.51	....	...	1.07
Kan. City, St. Jo. & Council Bluffs	37	37	.....	... .	.....	123,794	3,346	5.04	18.74	....	....	. ..	78.61	16.40	5.27	3.75	7.61	0.17	0.94	6.79	0.05	19.31	....	...	1.95
Lake Shore & Mich. Southern	593	....	380,903	746,602	370,316	1,498,121	2,796	....	....	67.78	96.91	41.96	75.82	....	....	2.98	5.70	0.06	0.12	6.89	0.19	15.94	....	...	1.56
Louisville & Nashville	....	....	.. .	.... ..	.....	.. .	....	.. .	....	....	..	....	....	....	....	...	....	....	....	....	....	....	....	....	....
Manhattan Elevated	....	302	700,832	.....	62,360	763,192	2,501	....	....	...	....	....	48.19	....	....	2.40	9.60	0.30	....	9.00	....	21.30	....	....	3.99
Mexican Central	....	....	...	....	....	.....	...	....	....	....	....	....	....	....	....	...	....	....	....	....	....	....	....	....	....
Minn., St. Paul & Sault Ste. Marie	104	74	76,471	116,172	22,712	215,355	2,910	4.49	19.16	....	....	....	82.68	....	6.15	5.85	14.87	0.26	....	6.55	....	27.52	5.30	1.76	3.57
Missouri Pacific	351	....	.....	.....	.....	847,198	2,973	4.39	16.67	....	....	....	99.15	....	....	4.50	6.88	0.34	1.44	6.49	1.61	21.26	3.76	1.56	1.36
Mobile & Ohio	107	83	68,642	139,380	50,129	258,151	3,109	....	....	....	....	...	70.49	....	....	3.21	5.05	0.20	0.68	5.33	0.93	15.40	....	....	1.48
N. O. and Northeastern	....	....	.....	.....	.....	.....	.....	....	....	....	....	....	....	....	....	...	....	....	....	....	....	....	....	....	....
N. Y., Lake Erie & Western	632	411	390,519	629,715	211,671	1,231,905	2,997	4.20	21.40	96.50	146.00	109.35	117.28	22.80	6.80	5.66	8.33	0.38	2.68	7.43	1.35	25.83	....	....	1.41
N. Y., N. H. & H., Old Colony Div	....	....	368,370	141,378	170,184	675,965	....	3.70	15.10	....	....	....	69.80	19.50	6.40	3.49	10.47	0.66	....	7.27	0.83	22.72	....	....	...
N. Y., Pennsylvania & Ohio	279	176	113,589	296,136	104,982	514,707	2,924	5.10	18.29	85.60	151.10	99.05	111.88	16.60	8.30	4.80	6.53	0.32	2.96	7.05	1.22	22.88	....	. ..	1.05
Norfolk & Western, Gen. East. Div.†	....	....	84,440	215,265	42,880	342,585	2,239	4.88	20.97	49.92	132.05	....	90.99	10.23	6.30	5.41	3.88	0.30	....	....	....	9.59	....	....	3.50
General Western Division†	....	....	90,629	258,493	44,893	394,015	2,462	5.46	17.72	84.00	137.00	....	127.00	15.34	8.68	5.21	4.46	0.28	....	....	....	9.95	....	....	....
Ohio and Mississippi	....	...	.....	.....	.....	.....	....	....	....	....	....	....	....	....	....	...	....	....	....	....	....	....	....	....	....
Philadelphia & Reading	....	...	384,485	256,998	697,112	1,338,545	....	....	....	....	....	...	86.21	...	...	4.05	4.97	0.35	....	5.77	0.48	15.62	....	...	....
Southern Pacific, Pacific System	726	632	581,326	577,877	244,328	1,403,531	2,221	5.32	13.68	....	....	....	66.64	....	. ..	6.19	16.00	0.21	2.32	7.36	1.30	33.38	....	....	4.80
Union Pacific	....	....	.....	.....	.....	.....	.....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Wabash	418	327	391,144	533,638	190,649	1,115,431	3,411	4.43	15.80	68.70	116.00	66.62	93.28	16.62	7.33	3.28	5.21	0.28	....	6.13	0.87	15.77	3.03	1.16	1.15
Wisconsin Central	149	97	106,030	139,485	43,118	288,633	2,975	....	....	....	....	....	86.06	....	....	2.99	9.80	0.16	...	7.26	...	20.21	...	....	2.25

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars. Empty cars which are reckoned as one loaded car are not given upon all of the official reports, from which the above table is compiled. The Union and Southern Pacific, and New York, New Haven & Hartford rate two empties as one loaded; the Kansas City, St. Joseph & Council Bluffs and Hannibal & St. Joseph Railroads rate three empties as two loaded; and the Missouri Pacific and the Wabash Railroads rate five empties as three loaded, so the average may be taken as practically two empties to one loaded.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

under his engine. A brake lever was suddenly thrown out against his head, killing him instantly.

Clarksville, Tenn., April 5.—While a freight train on the C. & O. Railroad was passing Cumberland City Station this evening, some one threw a stone into the cab, striking the fireman over the eye, inflicting quite a severe injury.

Batavia, N. Y., April 5.—A tire on an engine of the Lehigh Valley Railroad broke while the engine was running at the rate of 35 miles an hour near here this afternoon. The fireman and engineer were slightly injured.

Rouse's Point, N. Y., April 5.—A misplaced switch caused the derailment of a train on the Delaware & Hudson Canal Company's Railroad at this point this morning. A man in front of the switch lights prevented the engineer from seeing the open switch. The engineer and fireman escaped with slight injuries.

Lake Benton, Minn., April 6.—A regular west-bound passenger train on the Winona & St. Peter branch of the Chicago & Northwestern Railroad, jumped the track half a mile east of here to-day. Engineer Ed. Frary was instantly crushed to death under the engine.

Cairo, Ill., April 6.—Engineer Charles H. Norris, of the Illinois Central Road, had his legs so badly crushed that they had to be amputated, as the result of a collision between his engine and some cars at this point this evening. The shock of the collision threw the throttle wide open and the engine ran down the track.

Dalleston, Pa., April 7.—A gas explosion in the fire-box of the Philadelphia & Reading Railroad engine, causing the flames to shoot out at the door, burned Isaac Van Pelt, fireman of the engine, about the head and face very badly this afternoon.

New Era, Mich., April 9.—An engine on a logging railroad belonging to Staples & Covel ran into a tree and was knocked over a 16-ft. embankment, carrying nine men with it. Among the killed were Adolph Shelander, engineer, and Gus Anderson, fireman.

Port Chester, N. Y., April 12.—An express train on the New York, New Haven & Hartford Railroad ran into a caboose at this point to-day. James Gaffney, fireman of the express train, was severely hurt about the arms, body, and face.

Lancaster, Pa., April 13.—An engine on the Pennsylvania Railroad, while running backward and hauling a caboose, was derailed at this point to-day. The wheels of the pony truck left the rails, pierced the caboose, and cut it into fragments. Fireman I. C. Cover had his hip injured by leaping from the engine.

Pottsville, Pa., April 13.—There was a collision at Morris Junction of the Philadelphia & Erie Division of the Pennsylvania Railroad, between a Lehigh Valley passenger train and the Pennsylvania train of empty cars. The engineer of the passenger train was thrown off his engine and badly bruised.

Hilliard, Wyo. Ter., April 14.—A train on the Union Pacific Railroad was ditched half a mile east of here to-night. H. George, fireman, and William Lethbridge, the engineer, were instantly killed.

Hazleton, Pa., April 15.—There was a collision between a Pennsylvania freight and a Lehigh Valley express train at Silver Brook at noon to-day. Engineer Kimmel, of the freight train, had his eye cut and back and head bruised. Fireman Art Brown had one leg broken and was otherwise injured.

Salt Lake City, April 17.—A landslide occurred at Weaver Cañon, on the Union Pacific Railroad, to-day, causing an accident to a freight train. The fireman of the engine had one leg broken.

Reading, Pa., April 18.—Philip M. Lehr, a fireman on a passenger train of the Pennsylvania Railroad, was leaning out of his cab north of here, and was caught by a signal post and dragged from the engine. His skull was crushed.

Goshen, Ind., April 19.—An express train on the Lake Shore & Michigan Southern Railroad ran into the caboose of a freight train standing on the track that did not clear the main track, at Dunlap to-day. Engineer Charles Melcher remained at his post and was very severely injured. Fireman Nopper jumped and sustained severe injuries by being thrown against the fence.

Watertown, N. Y., April 19.—While a train on the Rome, Watertown & Ogdensburg Railroad was standing on the Y at Theresa Junction, waiting for another train to pass, the latter came down and ran through an open switch at the rate of 30 miles an hour, crushing into the engine of the waiting train. The engine of the latter was driven back against the tender, catching the engineer as it went and killing him. The fireman jumped and broke his leg.

Calais, Me., April 19.—The locomotive and tender of a train on the Shore Line Railroad left the rails near here this morning. The engineer was severely injured. The accident was caused by the spreading of the rails.

Denver, Col., April 19.—A passenger train on the Burlington & Missouri Railroad was ditched to-day by a sand drift on the track near Yuma, Col. Engineer Pat Quinlan and Fireman Bert Goodwin were seriously hurt.

Carlisle, Pa., April 20.—A passenger train on the Cumberland Valley Railroad struck an empty box car that had been blown by the wind from a siding on to the main track, about 3 miles south of here to-night. The engine fell over on its side, and both engineer and fireman were jammed between the engine and tender, but escaped serious injury.

Hartford City, Ind., April 21.—A Pan Handle freight train plunged down an embankment near here to-day. J. A. Phillips, the engineer, was fatally injured, and C. L. Tucker, the fireman, had both legs broken. The accident was caused by the engineer running into an open switch, believing he was on the main track.

Lancaster, N. H., April 22.—A freight train on the Grand Trunk Railway ran into a washout at a bridge over the Nulhegan River, near Wenlock, to-night. The engineer was killed and the fireman badly injured.

Sherman, Tex., April 26.—A freight train on the Houston & Texas Central Railroad was wrecked 1 mile north of Van Alstyne this morning. Circumstances indicate a premeditated case of train-wrecking. A cross-tie placed near the cattle guard was the obstruction. Charlie Clappert, the engineer, was slightly scratched.

Patchogue, L. I., April 26.—Eugene Bancroft, an engineer on the Long Island Railroad, was stepping from his engine this morning when he slipped and fell between the driving-wheels. Both legs were crushed, the right one being entirely severed at the hip.

Winnipeg, Manitoba, April 27.—A broken rail caused an engine and three cars to leave the track of the Canadian Pacific Railroad near here to-day. The engineer was seriously hurt.

Houston, Tex., April 28.—On the Atchison, Topeka & Santa Fé Railroad, between Kenny and Bellville, a rock train ran into the rear of a freight, telescoping the freight and several of the cars. Dad Christian, the engineer of the rock train, was badly hurt.

St. Louis, Mo., April 30.—Two switch engines with heavy trains behind them collided in the yards of the St. Louis, Keokuk & Northwestern Railway to-night. C. Berkshaw, a fireman, was scalded to death.

Jacksonville, Fla., April 30.—A train on the Florida Central & Peninsula Railroad jumped the track and went through a 30-ft. trestle near Plant City, Fla. The locomotive turned a complete somersault, and the engineer went down under it. His legs were crushed and his head and shoulders badly scalded.

Our report for April, it will be seen, includes 28 accidents, in which 5 engineers and 5 firemen were killed, and 15 engineers and 14 firemen were injured. The causes of the accidents may be classified as follows:

Broken rail	1
Broken tire	1
Collisions	8
Defective air-brake	1
Derailments	6
Falling from engine	1
Gas explosion	1
Landslide	2
Misplaced switch	3
Obstruction on track	1
Stone-throwing	1
Struck by obstruction	1
Train-wreckers	1
Washout	1
Total	28

PROCEEDINGS OF SOCIETIES.

American Society of Mechanical Engineers.—The announcement has been sent out that the spring meeting of this Society will be held at Montreal, Canada, from June 5 to June 9. The opening session will be held at Molson Hall, at McGill University, at 8.30 P.M. of Tuesday. The following papers will be read and discussed: A. K. Mansfield, Notes on the Theory of Shaft Governors; Albert F. Hall, Heat Units and the Specifications for Pumping Engines; W. H. Bristol, A New Recording Pressure Gauge for Extremely High Ranges of Pressure; Frank Richards, A Note on Compressed Air; A. W.

Robinson, The Relation of the Drawing Office to the Shop in Manufacturing; R. H. Thurston, The Theory of the Steam Jacket; Current Practice; D. S. Jacobus, Results of Experiments with a 50-H.P. Single Non condensing Ball & Wood Engine to Determine the Influence of Compression on Water Consumption; Frank H. Ball, Cylinder Proportions for Compound Engines, Determined by their Free Expansion Losses; F. M. Rites, A New Method of Compound Steam Distribution; Jesse M. Smith, Tests of a Small Electric Railway Plant; W. S. Aldrich, Power Losses in the Transmissive Machinery of Central Stations; M. P. Wood, Rustless Coatings for Iron and Steel; James McBride, Corrosion of Steam Drums; C. W. Hunt, A New Mechanical Fluid; F. R. Hutton, First Stationary Steam Engines in America; DeCourcy May, Cost of an Indicated H.P.; John R. Freeman, A New Form of Canal Waste Weir; G. W. Bissell, Effect of Varying the Weight of the Regenerator in a Hot-air Engine; W. R. Roney, Mechanical Draft for Boilers; R. C. Carpenter, The Saturation Curve as a Reference Line for Indicator Diagrams; Denton-Jacobus-Rice, Results of Measurement of the Water Consumption of an Unjacketed 1,600 H.P. Compound Harris-Corliss Engine; F. B. King, Notes on the Corrosion of a Cast-steel Propeller Blade.

The social entertainments will consist of an informal drive about Mont Royal Park, an excursion by special train to Lachine and down the rapids, an excursion to the dredging operations conducted in the harbor, visits to the Montreal Street Railway Company's power house, with luncheon and inspection of the power plant, a garden party at the house of Mrs. J. H. R. Molson, and an excursion to Ottawa by special train over the Canadian Pacific Railroad. Notice has been sent out by the Secretary that an effort is being made to secure the facilities of a special train by way of the Vermont Central Railroad, so that passengers from New York City, meeting the New England contingent in cars from Boston at White River Junction, can enjoy the pleasures of a journey at no greater cost than the regular rate, and perhaps at a reduction of fare. The train will probably leave New York at ten o'clock Monday morning, June 4. The headquarters are to be at the Windsor Hotel, where the rates are from $3 to $3.50 per day. Members are specially requested to wear the button badge used at conventions, as they render social acquaintance more easy.

Engineers' Society of Western Pennsylvania.—At the regular meeting of March 20, Mr. Thomas B. Nichols read a paper describing the emerald mines of Muzo, in the Republic of Colombia, South America. These mines have been worked for upward of two hundred years, and were known long before the Spaniards explored and took possession of the country, and they are still said to be the richest emerald mines in the world. The entrance to the mines is at the end of a ridge, near the junction of two mountain streams. The rock is bituminous black limestone, for the most part laminated like slate, the slabs being 2 or 3 in. thick. These are separated from each other by layers of a black powder. This formation is thickly crossed by innumerable veins of carbonate of lime, in the intersections of which veins the emeralds, in a rough state, are found, generally associated with crystals of a transparent quartz and a yellow mineral not yet classified. The finest stones are found in the black powder. The mine itself is in a deep basin excavated back of a sharp ridge, and is about 600 ft. in diameter and 100 ft. deep. The water from the mine is drained from it through a trough about 150 ft. to an adjoining brook. In the rainy season this brook becomes a furious torrent.

In the center of the mine, a little to the left, is placed a small shed, where the superintendent can watch the operations of the miners. The only tool these miners use is an iron crowbar ¾ in. thick, with a chisel edge, and weighing 25 lbs. With this instrument the rock is broken and allowed to fall into a sluiceway beneath. Water is collected in a tank above. When the quantity is sufficient, it is let fall on the mass below, and by this means the débris is washed away, leaving the emeralds in the sluices. Every evening the sluices are carefully examined and the emeralds collected. Even the close watching of the superintendent, however, fails to get all the emeralds for the mine owners, for a great many of the stones are stolen by the miners, who, as a general rule, are not very honest. A former manager of the mines, with whom I was acquainted, told me that perhaps 25 per cent. of the gems never went into the hands of the company, but were taken by workmen and sold on their own account. The demand for the stones influences the number of workmen employed This number varies at times from 50 to 500. They are fed by the company, and it costs 20 cents a day to feed each man. Their wages vary from 20 to 40 cents a day.

The mines are owned by the Colombian Government, but are operated by an English company, which rents them from the owners. The mines are two in number. Before the fall of Napoleon III. the Empress Eugenie was said to possess the largest emerald in the world.

Association of Engineers of the South.—At a recent meeting Mr. Samuel Wallace gave a talk on paints, bringing out considerable valuable and interesting information. Among other things he gave a description of the best method of painting ironwork, in which he recommended that the first coat should consist of pure red lead in powder and raw oil to be used within two or three weeks after mixing, and to be kept thoroughly mixed while using. This will dry in from 24 to 30 hours. The red lead should be ground in a mill, if possible, immediately before using. If the finish is to be black, use two coats made from paste consisting of 65 per cent. pigment and 35 per cent. raw oil. The pigment to consist of 65 per cent. sulphate of lime, 30 per cent. lampblack, and 5 per cent. red lead as a dryer. The whole thinned to a proper consistency with pure boiled oil. This paint ready for use will cost about 65 cents per gallon. If the finish is to be in red or brown, use a paste consisting of 75 per cent. pigment and 25 per cent. pure raw oil. The pigment to consist of 55 per cent. sulphate of lime, 40 per cent. oxide of iron free from sulphur and caustic substances, and 5 per cent. carbonate of lime as a dryer. The sulphate of lime to be fully hydrated. This paint will cost, ready for use, about 60 cents per gallon. Lead paints are not recommended for finishing coats on account of chalking, neither is zinc on account of cracking. Graphite paint does not dry well in linseed oil, and is not impervious to water. The color is steel gray. Both white and red lead should be thoroughly tested for purity.

International Railway Congress.—The International Railway Congress, which is attended by representatives from all of the European railways, will hold its next session in London in the month of June, 1895. This next session will be the fifth, the preceding reunions having taken place at Brussels, Paris, Milan and St. Petersburg, having had its origin at the centennial celebration of the introduction of railways in Belgium, to which a great number of railway men were invited. This reunion was so successful that it was decided to create a permanent organization for the purpose of organizing others in different centers of railway activity. The permanent office of the commission is at Brussels, and it is composed of 30 members renewed in thirds at each session. The association is certainly very unique, and seems admirably organized for obtaining the maximum results at the work of the session. The present President is Sir Andrew Fairburn, General Manager of the Great Northern Railway of England, and member of the Executive Committee. The Vice-President is Mr. Emlyn, Vice-President of the Great Western Railway, and the Secretary is W. W. Ackworth. The association of English railways, who have appointed a special committee for the reception of the guests in great number, have selected Mr. Ackworth as secretary of this committee, and upon him will fall the greater part of the duties of taking charge of the concourse.

Civil Engineers' Society of St. Paul.—At a meeting held on May 7 Mr. O. Claussen read a paper on the Requirements of Municipal Electric Light Plant Installation, advocating the location of the power house near a plentiful supply of water, in order that compound condensing engines might be used, and yet far enough from the business center to escape excessive cost of real estate, while near enough to profit by transportation facilities. Tiled floors were recommended for the engine and dynamo rooms, with rubber mats that were to be placed where necessary for protective insulation. A traveling crane as a fixture would assist in handling the equipment. The machinery and foundations were to be massive and of hard-burned brick laid in Portland cement. He favored low speed triple-expansion engines, water-tube boilers, extra feed pump capacity, economizers and smoke consumers. Steam pipes were to be furnished with magnesia casing and fitted with numerous valves in case of accident.

Association of Engineers of Virginia.—At a meeting on April 18 Mr. G. R. Henderson read a paper on boiler construction, in which he gave an interesting description of a modern boiler plant, where a short stack with a fan was used to regulate the draft instead of the usual very expensive stack, and where the fuel was not handled except by the mechanical means after it was dumped by the teamster until the ashes were let into the cart to be taken away. Also of the latest designs of water-tube boilers, showing the novelties of their

construction. Novelties of details were also given, among them a description of the Serves ribbed tubes, accompanied by an extract of a paper read by M. Kéromnès before the French Society of Civil Engineers, which showed an economy, in a locomotive test, of from 15 to 20 per cent. for the Serves tubes over the smooth tubes. The large excess in first cost will probably prevent their early introduction in this country except where fuel is very dear.

Engineers' Club of Cincinnati.—At a recent meeting Mr. C. Wood, Chief Engineer of the Cincinnati, Hamilton & Dayton Railroad, read a paper on the construction of a new freight house recently built by his Company at Cincinnati for outbound business. The principal building, and an additional covered platform of brick pavement, are constructed of iron-work, having posts of four angles latticed, resting in cast-iron shoes filled with concrete, purlins, trusses, and all parts of iron. The sides above the sash over the doors and the roof are covered with galvanized iron. Floor of 3-in. oak stringers bedded in cinders. Rolling steel shutters made in two 10-ft. parts in 20-ft. space, with the post between hung on pivot so as to allow of being swung back, thus making opening 20 ft. clear.

Engineers' Club of St. Louis.—At a meeting of April 11 Mr. J. A. Laird read a paper on the new machinery being installed at the water-works. In referring to the details of the pumping engines, he said that the shaft of the high-service engine No. 6 is of nickel steel 92,000 lbs. tensile strength and 22 per cent. elongation in four diameters. The capacity and duty tests on the Chain of Rock engines are to be for 720 consecutive hours. There is a 15-ton electric traveling crane in the engine house at the Chain of Rocks; vertical hoist, 80 ft. It has not caused a moment's delay in nine months' use, and is looked after and run by an ordinary helper. There are separate steam mains for each pair of engines. All feed-water will be metered. The running of the entire plant will be made as near as possible a perpetual duty trial.

American Railway Master Mechanics' Association.—The Secretary has sent out a final circular calling attention to the fact that the annual convention will meet at Saratoga, N. Y., at 9 A.M. June 18; the headquarters of the Association to be at Congress Hall. Members and others intending to be present should apply to Mr. H. S. Clemens, Congress Hall. The charge where no extras are furnished will be $3 for each person.

The Secretary has also issued another circular in which he states that there will be two vacancies for scholars at Stevens' Institute of Technology in September next. Sons of members and of deceased members only are eligible. Those desiring particulars of the entering examination will receive the same by writing to Angus Sinclair, 5 Beekman Street, New York.

Master Car-Builders' Association.—Secretary Cloud has sent out a circular calling attention to the announcement of the fact that the twenty-eighth annual convention of this Association will be held at Saratoga, with headquarters at Congress Hall, the first session of the convention to be called to order at 9 A.M. Tuesday, June 12. Members and others are again reminded that application for rooms should be addressed to A. H. Clements, Manager of Congress Hall, who has made arrangements for the usual accommodations to all in attendance at the rate of $3 per day.

Boston Society of Civil Engineers.—At a meeting held on April 18, Mr. A. L. Plimpton, Chief Engineer of the West End Street Railway Company, gave an interesting account of the experience that they had in welding tracks electrically, illustrating his remarks by blackboard sketches and specimens of welded joints.

PERSONALS.

THE title of Mr. E. W. GRIEVES, Master Car-Builder of the Baltimore & Ohio Railroad, has been changed to Superintendent of Car Department, with headquarters at Camden Station, Baltimore. The duties of the Superintendent of Car Department will be the same as those heretofore discharged by the Master Car-Builder, and he will report to the General Manager.

THE title of Mr. WALTER ANCKER, Supervisor of Floating Equipment on the same road, has been changed to Superintendent of Floating Equipment, with headquarters at Camden Station, Baltimore. In addition to the duties heretofore pertaining to the position of Supervisor of Floating Equipment, he will have charge of the repair and maintenance of the Company's wharf, dock, pier, and bulkhead properties.

MR. E. E. POSEY has been appointed General Passenger Agent of the Mobile & Ohio Railroad Company, with headquarters at Mobile, Ala. He will confer from time to time with the General Manager and General Auditor upon matters pertaining to the passenger department.

FRANCIS M. SIMONDS has opened a laboratory at 20 Platt Street, New York City, for purposes of making original investigations or experiments in chemical and metallurgical processes, including the analyzing and assaying of ores.

MR. EDWARD F. LUCE has been appointed General Agent of the Detroit Lubricating Company, with headquarters at Chicago, and the Chicago office has been removed from the Western Union Building to No. 941 Rookery Building.

MR. J. F. SCOTT, Master Car-builder of the Evans & Terre Haute Railroad Company, has resigned, and the office has been abolished. MR. JOHN TORRENCE has been appointed Superintendent of Motive Power and Rolling Stock. This order took effect on May 15.

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL.

[BY GEORGE H. THOMSON.

MATERIALS FOR STEEL BRIDGES.

GENERAL.—1. All of the materials used in the manufacture of the bridges shall fully and strictly conform to the several specifications as follows:

A. Specifications for raw materials.

B. Specifications for ingots.

C. Specifications for rolled steel.

2. The materials used in the manufacture of bridges shall be made from the raw materials to the finished product at one establishment.

3. The finished material shall not be shipped from the rolling mills until the Inspector of Rolled Steel has duly accepted and marked the same.

4. The Consulting Engineer reserves the right to reject all the steel from any special cast that has passed the requirement of three specifications above enumerated, provided, however, that three out of five specimens selected at random by him, from material rolled from said special cast shall show evidence of "piping" or lamination.

5. Materials for steel bridges shall be ordered upon bills approved by the Consulting Engineer. The contractor shall submit in triplicate form complete, correct, and legible bills, exhibiting the order numbers, name or number of bridge covered by the order, giving the location of the furnaces and mills where the ingots are cast and the steel is to be rolled. Should the Consulting Engineer approve the bills two copies shall be retained by him and one returned to the contractor.

6. The Consulting Engineer reserves the right to make such analysis, examinations, etc., on ingots and finished material, either physical or chemical, as he deems necessary to arrive at a thorough knowledge of the solidity of the ingots or the physical or chemical character of the rolled product; and the contractor shall furnish such pieces of identified finished material for examination as the Consulting Engineer may require.

7. The Consulting Engineer reserves the right to mark all rejected finished material with a permanent mark of identification.

8. The expense of inspection of the raw materials, the inspection of ingots, and the inspection of rolled steel, including the *record* and identification of the same, together with the cost of chemical and occasional microscopic work, shall be borne by the contractor. The inspectors shall be appointed by the Consulting Engineer.

9. These specifications throughout are subject to the interpretation of the Consulting Engineer.

SPECIFICATIONS FOR RAW MATERIALS USED IN THE MANUFACTURE OF STEEL FOR INGOTS.

1. All raw material used in the manufacture of steel ingots shall be chemically within the Bessemer limit of the following proportions of 1 per cent.:

Sulphur	.05
Phosphorus	.10
Copper	.40

2. All raw materials shall be subject to the acceptance or rejection of the Inspector of Raw Materials.

3. The contractor shall furnish to the Inspector of Raw Materials complete and correct reports of all raw materials to be used in every heat prior to charging the same into the furnaces.

4. The Inspector of Raw Materials shall have free access at all times to all stock piles and other stores of raw materials, and the contractor is to furnish said inspector all reasonable data and facilities to assist him in the inspection and identification of all raw materials.

5. Rejected raw materials shall not be used in the manufacture of ingots.

SPECIFICATIONS FOR THE MANUFACTURE OF INGOTS.

1. All ingots must be cast from steel melted in an acid-lined open-hearth furnace.

2. The ingots shall be subject to the acceptance or rejection of the Inspector of Ingots.

3. No single ingot or casting shall (in order to avoid extreme segregation) exceed 15,000 lbs. in weight.

4. All ingots must be bottom cast.

5. No ingot shall be disturbed or removed from the position in which it is cast until it is sufficiently solidified to obviate "bleeding."

6. All ingots shall be duly marked for identification, and a complete and correct report of each cast, giving the number, size, and weight of each ingot, shall be furnished by the contractor to the Inspector of Ingots within five hours after the cast is made; and the contractor shall furnish said inspector such further data as he may require to assist him in keeping the record of the identity of the ingots.

7. The Inspector of Ingots shall have free access at all times to the works where the ingots are cast.

SPECIFICATIONS FOR ROLLED STEEL

1. Steel shall be rolled only from identified and duly accepted ingots.

2. Finished rolled steel shall show under analysis not more than the following proportions of 1 per cent.:

Phosphorus	.08
Sulphur	.04
Manganese	.45
Copper	.20

3. All finished rolled steel shall be straight, well finished in the rolling, full to dimensions and free from laminations, buckles, surface, edge, or other defects.

4. All finished rolled steel shall possess certain definite physical properties, which shall be determined by the Inspector of Rolled Steel from such test pieces (to be prepared by the contractor) as said inspector shall determine, as follows:

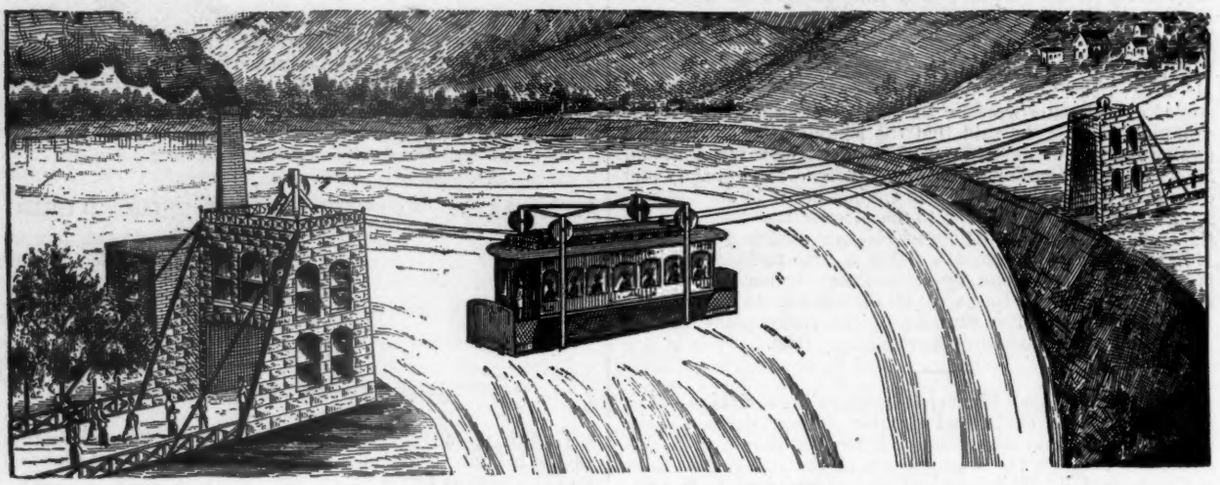
	Not less than lbs.	Not more than per sq. in.
Ultimate tensile strength plates and shapes	58,000	65,000
" " " rivet rod	50,000	54,000
Elastic limit plates and shapes	38,000	
Elongation plates and shapes under 36 in. wide 26 per cent. in 8 in. length.		
Elongation plates over 36 in. wide 24 per cent. in 8 in. length.		
Reduction of area plates and shapes 50 per cent.		
" rivet rod 60 " "		

5. The fractures of test pieces shall be mainly fine grained.

6. Finished rivet rod when heated to a red heat and upset for 3 in. of metal shall show (upon cutting out) a silky fracture.

7. Strips of finished material cut along the direction of rolling shall withstand cold bending, double upon itself under the hammer without visible cracking.

8. Prepared specimens cut from finished material at random shall show no "piping."



GAGNIER-GRIFFIN SUSPENDED BRIDGE RAILWAY.

INSTRUCTIONS TO INSPECTORS.

1. The Inspector of Rolled Steel will take general charge of inspection, appointing the Inspector of Raw Materials and the Inspector of Ingots. He will examine and check all orders, shipments, reports, tests, and other examinations, etc. He will record all rejected raw material, ingots, and rolled steel, and notify the contractor of the causes for rejection of the same.

2. The Inspector of Rolled Steel will direct the work of the Inspector of the Raw Materials, and see that he is very familiar with the several grades of raw material in current use at open-hearth furnaces; that he makes inspections personally; and that he identifies inspected raw materials; that he is on duty day and night when required; and that he turns over to the Inspector of Ingots a correct certificate and record of all identified raw materials accepted or rejected by him.

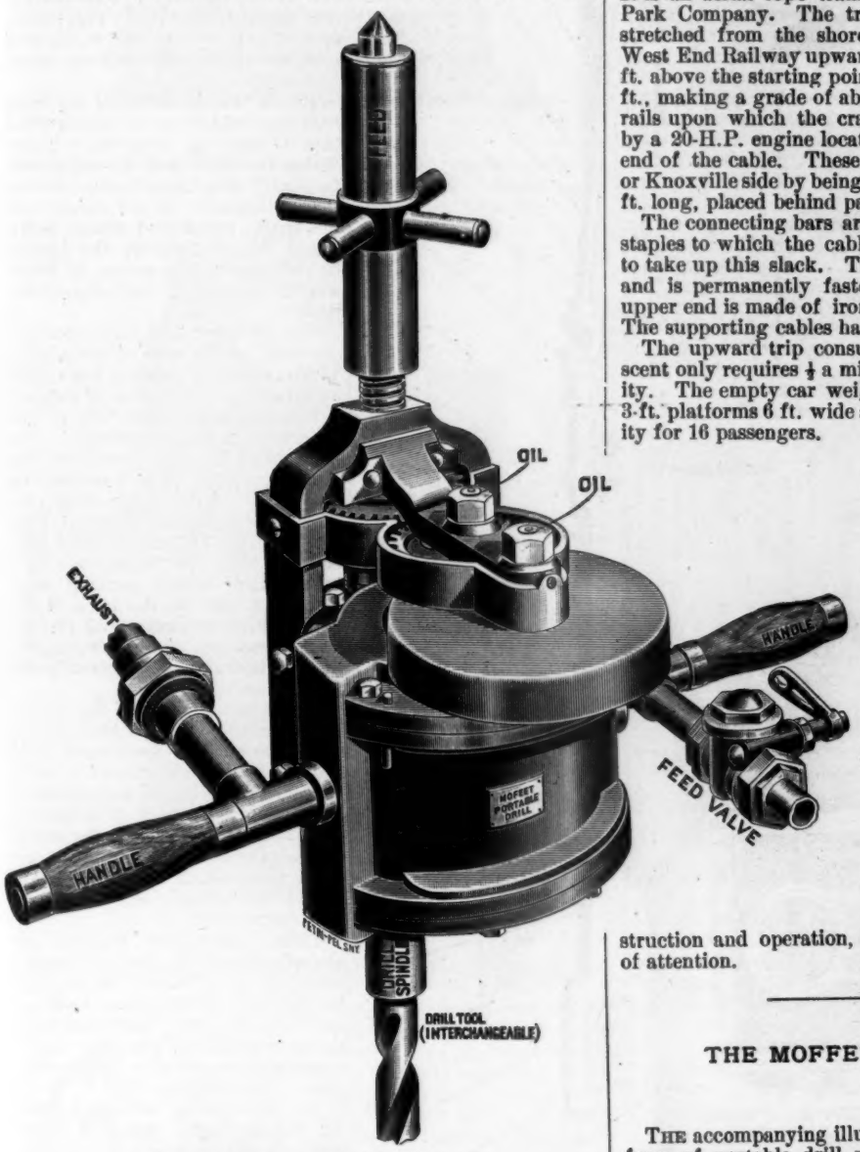
3. The Inspector of Rolled Steel will direct the work of the Inspector of Ingots and see that he is familiar with the work of the furnaces, the uniformity of the product, etc.; that he traces the raw materials to the charging of the same into the furnaces, and thence to the ingots, and thence to the mills, reporting the same to the Inspector of Rolled Steel; that he is on duty day and night when required; that he rejects "bled" ingots, or ingots not bottom cast; that he notes especially casts that have been too violently or quickly melted or burnt, and that he reports the same for special examination of steel rolled therefrom.

4. The Inspectors of Rolled Steel personally will inspect the rolling of material only from traced ingots, and he will from time to time test for the properties, chemical and physical, called for under the specifications for rolled steel. He will be on duty at all times required.

5. The Inspector of Rolled Steel shall establish and assign a value to all rolled steel inspected by him, and shall then record this value. Rolled steel which has been accepted by him as satisfying all the requirements of the specifications for rolled steel traced to accepted raw materials and ingots shall have an assigned value of 100.

Rolled steel which, more or less, fails to meet the requirement of the three specifications shall have an assigned value ascertained by the following rating :

For steel traced to accepted raw materials								15
"	"	"	"	"	ingots			15
"	"	satisfying clause 2d specifications rolled steel						10
"	"	"	"	3d	"	"	"	10
"	"	"	"	4th	"	"	"	30
"	"	"	"	5th	"	"	"	10
"	"	"	"	7th	"	"	"	10
Total								100



THE MOFFET PORTABLE DRILL.

In which clause 4th is divided into	Ultimate strength	5
	Elastic limit	15
	Elongation	5
	Reduction of area	5

6. The Inspector of Rolled Steel will accept all steel valued at 100 and reject all steel of less value.

7. The Inspector of Rolled Steel will not accept satisfactory testing machine results as conclusive evidence of the quality of the steel inspected further than its rating of 30 ; machine tests are to be considered as corroborative only, and of no value considered alone. All of the requirements of the specifications must be satisfied, and the whole taken together shall be the absolute criterion establishing the value of the steel before acceptance.

" . . . any test is liable to yield untrue results, either from incapacity or carelessness in those who use it."—*Herbert Spencer.*

Manufactures.

SUSPENSION RAILWAY AT KNOXVILLE.

THERE is a novel method of crossing the Tennessee River in use at Knoxville, Tenn., which was constructed by the Gagnier-Griffin Suspended Railway Bridge Company, of Chicago, Ill. It is an aerial rope tramway on the property of the Unakaa Park Company. The tramway consists of two 1⅛ in. cables stretched from the shore of the river at the terminus of the West End Railway upward to a bluff on the opposite bank 350 ft. above the starting point, the length of the span being 1,060 ft., making a grade of about 33 per cent. These cables form rails upon which the cradle travels, being hauled to and fro by a 20-H.P. engine located in the power-house at the lower end of the cable. These cables are anchored at the lower end or Knoxville side by being bolted to 12 × 12-in. bolt timbers 14 ft. long, placed behind partitions of 6-ft. plank.

The connecting bars are 12 ft. long and 1½ in. thick. The staples to which the cables are fastened have 24 in. of thread to take up this slack. The hauling cable is a ½-in. wire rope, and is permanently fastened to the car. The anchor at the upper end is made of iron plates fastened to the solid rock. The supporting cables have a breaking strength of 60 tons.

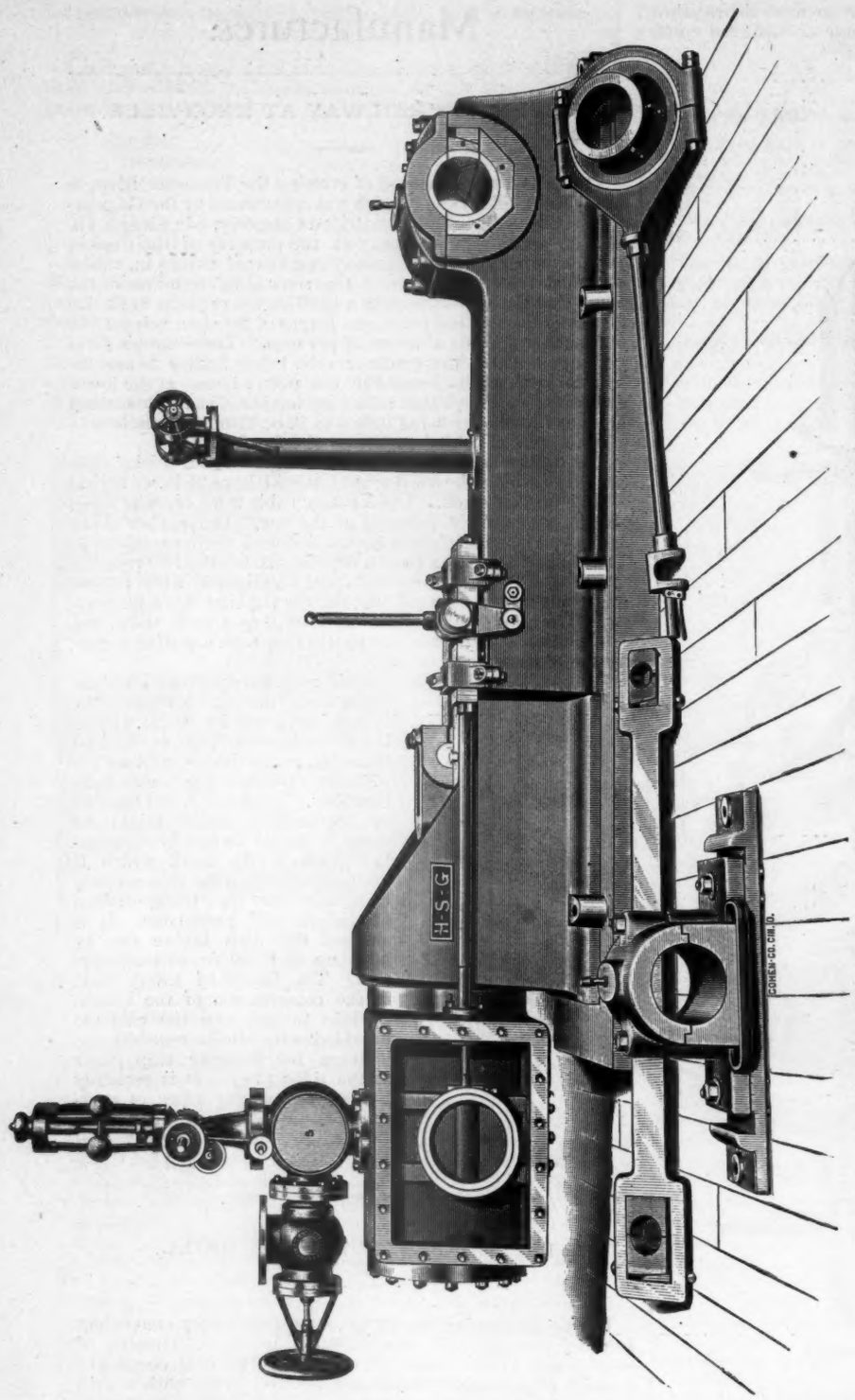
The upward trip consumes about 3½ minutes, while the descent only requires ¼ a minute, the car running down by gravity. The empty car weighs 1,200 lbs., has a 14-ft. body, and 3-ft. platforms 6 ft. wide and 6½ ft. high, with a seating capacity for 16 passengers.

This road merely exemplifies one of the many purposes for which the system designed by G. H. Griffin is excellently suited, and can be used in many industries as well as for pleasure resorts and mountain climbing. To mention the number of applications which might be made it would be merely recapitulating all of the work which is necessary to be done in mountain fastnesses for the transportation of freight and passengers. It is claimed that this bridge can be built up to 3,300 ft. without support. The factor of safety used in the construction of the system is eight to one, and the cars are provided with all the requisite appliances for insuring stop pages at the right place. It is certainly a novel and daring piece of engineering, and one which, in its construction and operation, will certainly attract a great deal of attention.

THE MOFFET PORTABLE DRILL.

THE accompanying illustration represents a very convenient form of portable drill manufactured by J. G. Timolat, of 89–91 South Fifth Avenue, New York. The drill consists of a small rotary engine connected by steel gears with a drill spindle carrying a taper socket at one extremity. The tool is intended to do away with the tedious operations of drilling with the ratchet, and the power applied can be either steam or compressed air at a pressure of not less than from 40 to 45 lbs.

The connection between the drill and the steam or air-pipe is made by means of flexible hose, the length of which determines the area within which the drill can be operated. The drill is fastened to the work in the same manner as a ratchet drill, and as it weighs but 45 lbs. this can be readily done. The capacity of the drill ranges from holes of ⅛ in. to 2½ in. in diameter, in steel, wrought or cast iron ; the speed for the different sizes of drills being regulated by the feed-valves and feed-screw without reducing the power below a satisfactory working point. When used as a reamer the weight of the tool carries the cutter through if it is operated vertically, and but a slight pressure is necessary for horizontal work.



DETAIL OF HEAVY-DUTY ENGINE, MANUFACTURED BY HOUSTON, STANWOOD & GAMBLE, CINCINNATI, OHIO.

bottom, so that in case of excessive wear the slide bars may be taken out and planed at any machine shop. The cross head, which has a babbitted bearing on top and bottom slides, is very heavy and has a large pin. This pin is of steel and is turned perfectly straight, and is secured in a straight hole which is carefully bored and reamed, and into which it is clamped by studs as shown. An end view of the valve stem guide is also shown in this cut. This guide, as well as the valve bar, is made of cast iron, and possesses large wearing surface.

Fig. 3 is a side view of the main bearing, which is so constructed that it may be removed without lifting the shaft and fly-wheel out. In doing this the eccentric is first moved laterally on the shaft, and the shaft, crank and wheel being raised slightly, enables the box to be withdrawn by means of hand-screws inserted in the holes shown in cut.

The cylinder has large ports 9 per cent. of the area of the piston. The travel of valve being large gives an excellent distribution of steam.

Fig. 4 is a sectional view of the slide-valve partially balanced. On the back of the valve is a plain ring bearing against planed surface on the inside of the steam-chest cap, which also embraces a round plug turned on back of valve. The joint between plug and ring is made tight by a plain spring packing ring. There is a hole on the back of the valve which connects with the exhaust passages of the engine, relieving the valve of pressure in this inner chamber.

Fig. 5 is a section of the piston. The packing is of Babbitt-Harris type, which has done such good service in Corliss engines for years. A peculiar feature of this piston is the junk ring, which is as wide as the piston. If the cylinder has to be re-bored, the owner does not have to purchase an entirely new piston, but simply the junk ring with its packing.

These heavy-duty engines are manufactured in the following sizes: 17 in. × 24 in., 18 in. × 26 in., 20 in. × 28 in., 22 in. × 30 in., and have heavy fly-wheels and large size governors. This firm makes a specialty of manufacturing slide-valve engines from 10 H.P. to 250 H.P. A "Ready Reference Book for Steam Users," which is of interest to all engineers, will be sent on application.

A HEAVY-DUTY SLIDE-VALVE ENGINE.

We here illustrate a new heavy-duty slide-valve engine manufactured in Cincinnati, O., by Houston, Stanwood & Gamble.

This engine is one of a series of large size engines which this firm terms "heavy-duty engines," on account of the large bearings and heavy design. These engines are used to a great extent in distilleries, planing mills, sawmills, rolling mills, and even in electric-light plants in localities where fuel is cheap.

Fig. 1 is a rear view of the engine dismantled, showing balanced slide valve, form of connecting and eccentric-rods, and the removable main bearing.

Fig. 2 shows a cross section of the bed taken through the slides. These slides are adjustable and removable, top and

L. S. G. GRAPHITE PAINT.

The Detroit Graphite Manufacturing Company are manufacturing a protective paint for wood and iron, which is composed of a natural product mined in the Lake Superior region of Michigan. This product is ground by special machinery which produces a pigment of extreme fineness and smoothness, and which is claimed to be absolutely uniform. As graphite is not affected by salt, acid, alkalies, or ordinary gases, it makes one of the best foundations possible for preservative paints. This special paint has been subjected for months to acids, alkalies, water, brine, sulphur fumes, etc., and it is guaranteed to be a sure protection against rust or corrosion of any metallic portions painted with it, under any circumstances and in any climate. The natural color is a very dark slate approaching a steel black, but it can be furnished in dark

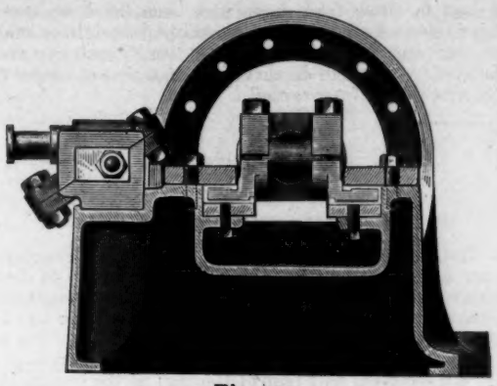


Fig. 2.

green, slate or brown, to black, suitable for regular surface painting and trimming for buildings. It is also claimed that wood painted with it and exposed to heat would char beneath

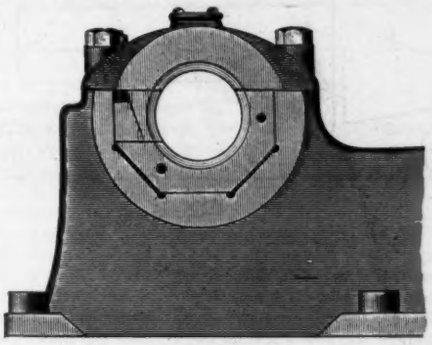


Fig. 3.

without burning the paint. Another feature which is very valuable, is that it is tenacious and elastic and will not scale off from metal, wood, brick or slate surfaces, while it con-

Fig. 4.

forms to the expansion and contraction of the metals painted with it.

The illustration which we present shows a common 2-bushel grain bag painted with this graphite paint in July, 1892, and which has been kept constantly filled with water ever since, without leaking. The bag is still soft and pliable, and although it has twice been frozen solid, it is still in a perfect condition. Not a drop of water has leaked, and it is apparently good for many years more of similar service. This is considered as the best of evidence of the waterproof and preservative qualities of this graphite paint.

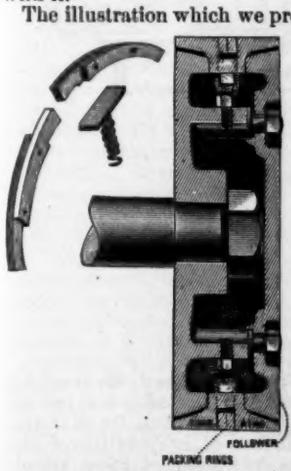
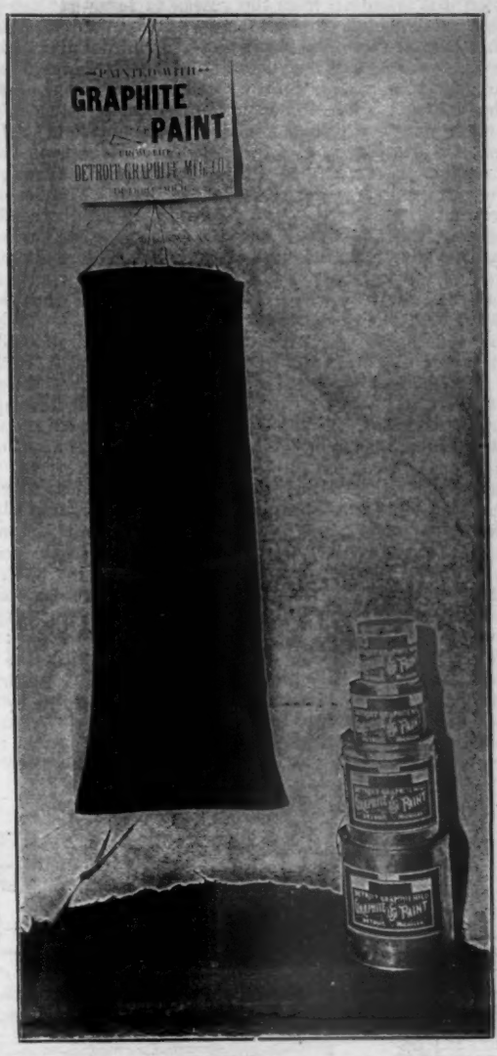


Fig. 5.

Another adaptation of the paint is the coating of boiler flues. About a year ago several flues were given a coat, and although it was thought at the time that they would not last six months, when examined a short time ago they were found to be in as perfect condition as when painted, while other flues in the same boiler, which had not been touched with the graphite, were badly corroded and scaled. The painted flues, on the other hand, had a clean and almost polished surface, to which it seems impossible for scale to adhere. This merely corroborates some of our own experience where the marks on boiler sheets stood



GRAIN BAG PAINTED WITH L. S. G. GRAPHITE PAINT.

out prominently and untouched by corrosion after several years of service, while the parts of the sheet which had not been touched with the marking paint were badly corroded and pitted, leaving the original marking projecting in a bold bas-relief.

EXPERIMENTS WITH SERVE TUBES MADE ON THE NORTHERN RAILWAY OF FRANCE.

By Kéromnès.

The Serve tubes are now being largely introduced in marine boilers, and have been for some time in use on locomotives of the Paris, Lyons & Marseilles Railway in France. The results of their trial on that railway were so satisfactory that the Northern Railway adopted them for three locomotives whose tube plates required renewal, and for 15 new locomotives under construction at Belfort, and the results obtained were excellent. The Serve tube differs from ordinary tubes in having eight internal radial ribs which serve to increase the heating surface.

The Northern Railway, in their first trials of these tubes, followed the example of the Paris, Lyons & Marseilles Company in using tubes of 2¼ in. diameter instead of the smooth tubes of 2 in previously in use. The number of tubes was greatly reduced, in some cases by one-half, while the heating

surface was at the same time largely increased, and the total section of the tubes open to the passage of the gases somewhat increased also. The surface in contact with the water was of course reduced, a matter of no consequence, since it is in any case greater than is necessary to transmit the heat at the rate at which it is taken up from the gases.

These trials being so satisfactory, it became a question whether Serve tubes of 2 in. diameter could not also be made to serve, since, if not, they could not be introduced except where new tube-plates were wanted. The experiments to which this paper is devoted were therefore undertaken. They were made with a stationary boiler of locomotive type, forming one of a group of four at the railway workshops of Forges de la Chapelle. Two fans, driven by Brotherhood engines, were used to represent the effect of the blast. The grate had an area of 14.4 sq. ft.; the tubes were 160 in number, 1.97 in. in diameter, and 14.65 ft. in length. The heating surface in the furnace was 82 sq. ft., and in the tubes (before alteration) 1,151 sq. ft.; the steam pressure was 92.4 lbs. per square inch. The boiler under trial was tested alone, and also when working along with the other boilers.

The first Serve tubes tried had ribs of a depth of 0.43 in., which raised the heating surface from 1,233 sq. ft. to 2,336 sq. ft., but reduced the section open to the passage of the gases from 2.84 sq. ft. to 2.56 sq. ft. With natural draft the vaporization per pound of coal was very slightly increased, the same amount of steam being made in the day with a somewhat reduced consumption. With forced draft, however, the production of steam per pound of coal was increased by as much as one-eighth, the best effect being got with a vacuum lying somewhere between 1¼ and 2¼ in. of water. The temperature in the smoke-box was lowered from 518° F. (with smooth tubes) to 338°. The temperature of the steam being 322°, it is seen that very little more use could possibly have been made of the combustion. The objection, however, to this experiment was that the tubes got often choked with ashes; and therefore a tube of 2.05 in. diameter was tried with ribs 0.35 in. in depth, the ribs extending to a length of 8.2 ft. only, and the rest of the tube being smooth. The section for the passage of gases was now increased to 2.69 sq. ft., and less choking of the tubes occurred; the efficiency was much the same as in the preceding case. Tubes of the same size were therefore tried with ribs of 0.275 in. projection, both extending the whole length of the tube, and also for a length of 8.2 ft. only. The results were much the same, whether the rib was of the full length of the tube or not, and showed a vaporization of 25 per cent. in excess of that of smooth tubes for the same amount of fuel, with a draft of 3 in. water pressure.

With tubes of this depth all difficulty as to choking disappeared. With the shallower ribs it was found that a greater draft gave maximum economy than with deeper ribs. The tubes used in these trials have now been fitted on two locomotives under repair, with an increase of weight in one case of 154 lbs., and in the other of 220 lbs. Fresh experiments will be made with them in service.—*Mémoires et compte rendu de la Société des Ingénieurs-civil.*

Recent Patents.

LOCOMOTIVE.

Mr. Richard Helmholtz, of Königsberg, Germany, has taken an American patent on the ingenious plan of locomotive illustrated by figs. 1, 2, 3, 4 and 5. Fig. 1 is a diagrammatic view, showing the general arrangement of parts; fig. 2 is a side view of the front part of the locomotive; fig. 3, a transverse section through the smoke-box on two different planes, and fig. 4 a sectional half plan of the part of the engine shown in fig. 2.

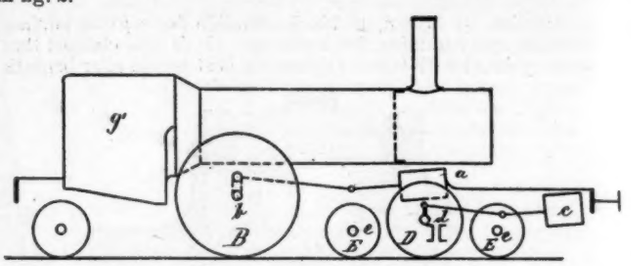


Fig. 1.

The objects and advantages of this invention are described as follows in the specification:

"In locomotives of ordinary construction having two pairs of drivers driven from one pair of cylinders, the dimensions of such cylinders must be such as to produce the maximum hauling power, which corresponds, as is well known, to the total weight resting upon the drivers. This construction has the objection that when a certain velocity is attained, the coupling of the drivers becomes superfluous, for the reason that the adhesion of one pair of drivers would be sufficient for the hauling power determined by the surface of evaporation of the boiler. Otherwise, smaller cylinders would, at these velocities, give better results than the dimensions calculated for the maximum hauling power. These two items: first, the heavier running of the drivers consequent on their being coupled, and second, the excessive dimensions of the steam cylinders, exert

Fig. 2.

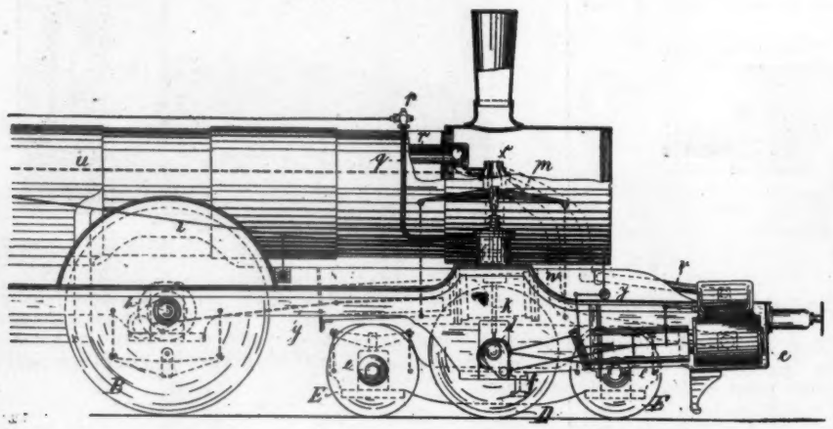


Fig. 3.

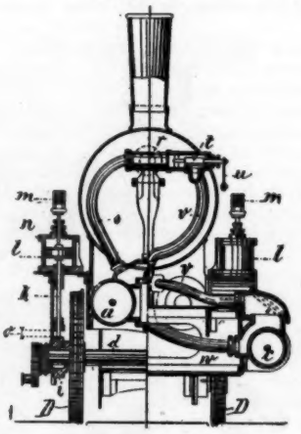
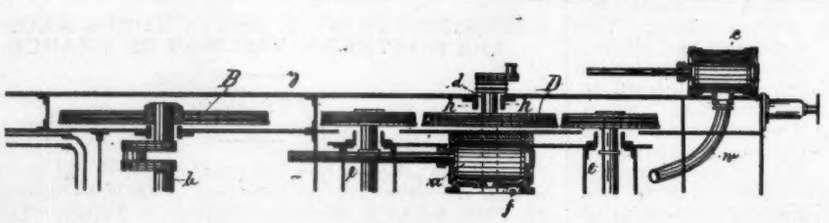


Fig. 4.



unfavorable influences on the working of the engine, and for this reason the best results at high velocity as well as the highest absolute velocities have been attained heretofore by uncoupled drivers or locomotives having but one pair of drivers.

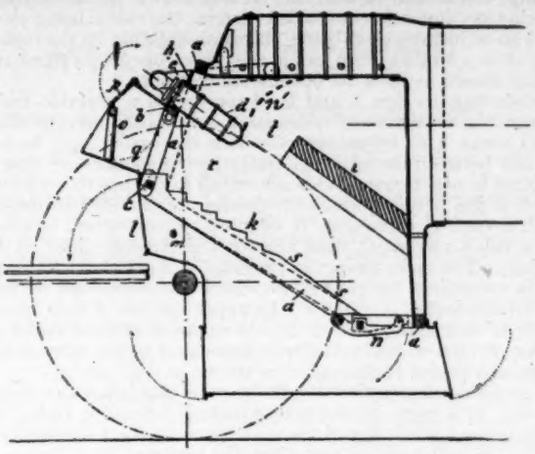


Fig. 5.

The use of such engines is, however, usually inconvenient by reason of the low hauling power of such engines.

The object of the present invention is to unite the advantages of the locomotive having uncoupled drivers whereby great velocity may be attained, with those of the locomotive having coupled drivers whereby great hauling power is imparted.

In the drawings *B* represents the main drivers driven from the main cylinders *a*, as seen in fig. 1, and *D* represents the auxiliary drivers driven from the auxiliary cylinders *c*. The main engine, with its inner cylinders *a* and the driven axle *b*, is provided with very large drivers, to be operated at all velocities, while the auxiliary engine, comprising the external cylinders *c* and driving axle *d*, is provided with driving-wheels of small diameter, and is intended to increase the hauling capacity of the locomotive. For this purpose I have provided means whereby the auxiliary engine may be stopped when the speed reaches the limit, and have also provided means whereby the forward driving-wheels *D* and their axle *d* may in such cases be raised clear of the track in order to reduce the load on the main cylinders. The axle *d* is placed between two axles *e e* of bearing truck wheels *E* properly united to a swinging or pivoted frame of well-known construction (seen in fig. 4) pivoted on a pin, *f*, to the main frame *g* of the engine.

The drawings show that the supplementary axle *d* is attached to bearings or jaws *h h* on the main frame, although it is not so described in the specifications, and the boxes slide vertically in the ordinary manner between them. The bearings *i* (fig. 3) of shaft or axle *d* are firmly connected with the spring actuated or elastic supports *k*. These spring supports *k* are in the nature of piston-rods, and bear pistons *n* arranged in the cylinders *l* through which they pass through stuffing-boxes in the ends thereof, and are connected to the leaf springs *m* (figs. 2 and 3); such springs being supported from the frame in any convenient manner are tensioned upwardly in order to keep the driving-wheels *D* normally lifted free from the track for a distance marked *o* in fig. 3 of the drawings. By means of a three-way cock *p* (fig. 2) and the pipes *q* steam is admitted to the space above the pistons in cylinders *l*, or said space is placed in communication with the atmosphere. The admission of steam thereinto has, as will be obvious, the effect of depressing the drivers *D* into contact with the rails.

The driving-wheels *D* are represented as having flanges, but these would not appear to be needed, as the truck would guide the engine and keep it on the track.

The patent has been assigned to the "Locomotiv Fabrik of Krauss & Company, Aktien-Gesellschaft," of Munich, and is numbered 516,436. The inventor also shows an application of his device to an engine with two pairs of driving-wheels.

VON DORMUS' LOCOMOTIVE FIRE-BOX.

Fig. 5 represents a form of fire-box and grate that has recently been patented in this and several European countries. The whole back end of the fire-box, it will be seen, is open, or, rather, is without a water space. Immediately over the furnace door or doors—for there are two of them—is a water leg, *d*. This is connected by pipes *e* with the sides of the fire-box, whereby the steam generated in the arch is conducted to the boiler and a circulation of water is maintained therein. Immediately below the water-leg *d* feed-box, *q*, is located. This has two doors, *p* and *o*; the former is just large enough to feed coal into the box and the latter extends the whole width of the fire-box, so as to facilitate the use of fire tools in working the fire. A door, *l*, gives access to the ash pan, and enables the fireman to rake out the ashes from the under side of the grate. The grate, it will be seen, has steps at its upper end, and is straight at its lower. These steps are intended to retain the coal until it is coked, and the grate is made straight at its lower end, so that when the coal is coked it will slide downward to the front end of the fire-box; *i* is a fire-brick arch of the usual form. The water-leg *d* acts as a deflector for the air, which may be admitted through the door *p*. The connection of this arch with the sides of the fire-box by outside pipes will not, it is thought, commend itself to locomotive superintendents. It seems as though a better method of construction would be to bring the crown-plate down, as indicated by the dotted line *n'*, which has been added to the patent drawing; the space *d* would then be connected directly with the inside of the boiler.

The general idea of this invention is to supply a feed-box which can be kept filled with coal, so that, when the door *p* is opened, there will be comparatively little air admitted, and that will be deflected downward over the fire. The coal in the feed-box will be heated and partially coked, and the volatile gases will then be distilled. As this process continues it will be fed downward on the grate, the lower portion of which will thus have a layer of incandescent smokeless fuel on it. The air passing through this will combine with the distilled gases when the two currents meet at *i*, and will thus be consumed.

Steeply inclined grates, similar to the one represented, never seem to have met with much favor in this country, and yet they seem to have much to recommend them. The patentee of this invention is Fritz Ritter von Dormus, of Florisdorf, Austria-Hungary. The number of his patent is 516,923.

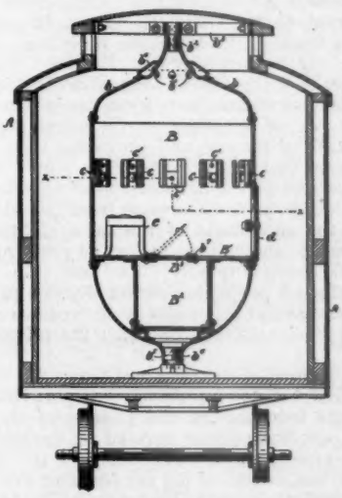


Fig. 6.

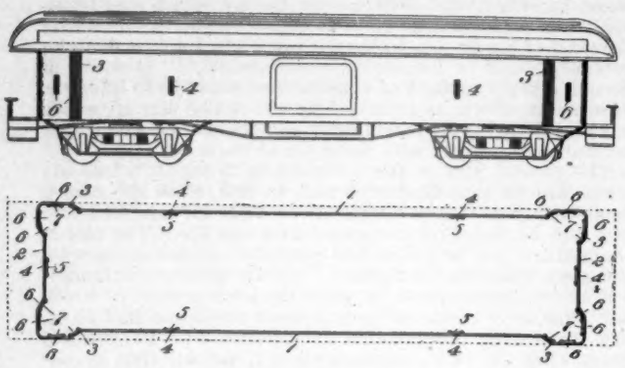
DEFENSIVE RAILROAD CAR.

Train robberies have become so frequent in this country that they have started inventors to provide means of prevention and defense. Mr. William D. Patterson, of Keokuk, Ia., has devised a means of defense against robbers which is shown in fig. 6. The objects of his invention he describes as follows: They are, first, to provide a railroad car with a simple, comparatively inexpensive, durable and safe apartment for a sentinel to be stationed, and with a vault connected therewith for the reception of valuables, whereby a practicably impregnable barrier is presented to the depredations of a class of outlaws or bandits that have become known as express and mail train robbers; and, second, to provide a railroad mail and money transportation car, with a compact burglar-proof apartment having a vault, and mounted in the car so as to permit of ready access being had to the interior thereof, and room afforded for passage along and around the apartment for entering the same, and having suitable ventilators and loop-holes and internal appliances to enable a sentinel or guard on watch therein to be prepared for any emergency that may arise, and

with fire-arms or the like so disposed and supported therein as to permit of their use when occasion arises through internally closed loop-holes of the apartment, the construction and arrangement being such as to render destruction of the apartment impossible or access to the interior exceedingly difficult.

Fig. 6 is a sectional view of a car and the "impregnable barrier" B, which is described as follows:

B is the shell of the burglar-proof apartment or chamber, which in this instance is in the form somewhat of a cage and constructed of iron, steel or other strong, impenetrable material, and having a contracted top, b, with radial apertures b' extending therethrough, and with a throat or stem, b^2, engaging with a cross bar, b^3, from the interior of the car from the top



Figs. 7 and 8.

thereof and for supporting said cage firmly to position; b^4 is a contracted hollow stem with a circular standard, b^5.

Suitable port-holes c with covers c', a seat, e, etc., enable the occupant of this fort to act on the offensive as well as defensive. The patent is No. 517,234.

Another inventor—Mr. Owen G. Cates, Jr., of St. Louis, Mo.—has been working in the same direction. A side view and plan of his car is shown by figs. 7 and 8. His invention, he says, consists in the peculiar formation of the side and end walls thereof in such manner as to form bastions in one or more corners of the car, or, in other words, forming offsets in the side and end walls of the car, and providing these offsets with port-holes covered by slides on the inside, which can be raised by the occupant and give him command of all sides of the car, thus enabling him to protect the same from intruders in safety.

1 indicates the side walls of the car and 2 the end walls thereof. These side and end walls, for the greater part of their length, extend uninterruptedly, but near the corners are formed with offsets 3 projecting outwardly to a plane beyond, from which the side and end walls of the corners are led, thus forming "faces" of bastions, of which the offsets 3 form the "flanks."

Arranged at suitable distances apart along the length of the side and end walls, 1 and 2 respectively, are port-holes 4 of a size sufficient for the introduction and passage of the barrel of a firm-arm, said port-holes being covered on the inside by slides 5 mounted in suitable ways. The offsets 3, or "flanks," and the "faces" of the corners of the car forming the bastions are similarly provided with port-holes 6 covered by suitable slides 7, as in the instance of the port-holes arranged along the side and end walls of the car. By the above arrangement it will be noticed that by the incorporation of the bastions in the car they do not detract from its symmetry, and the eaves of the car roof overhanging the same, these bastions offer no obstruction. It is also apparent that, if desired, offsets might also be arranged midway the length of the side walls, but this is hardly necessary in the present construction.

It would seem as though these two inventors ought to unite their interests. A car with Mr. Cates's "bastions" and Mr. Patterson's turret, with one or two courageous men who are good shots to form a garrison, would be a disagreeable place to attack.

CHECK VALVE.

Mr. Louis Schutte, of Philadelphia, has patented an invention which he says relates to horizontally moving check valves, the object being to provide a valve of this character which will be balanced so that the resistance offered to its opening and closing movements will be reduced to a minimum.

The invention consists primarily in combining with a valve seat, a horizontally moving valve adapted to close the same and sustained so as to be moved back and forth by links or equivalent supports pivotally connected to the valve on opposite sides of the same, and also in a stop constructed to limit the movement of the valve or to regulate the length of its "throw."

Fig. 1 is a vertical sectional elevation of a valve and casing having my invention embodied therein, the valve being closed and an adjustable stop being shown to regulate its movement. Fig. 2 is a similar view with the valve opened, a fixed stop being shown to limit its opening movement.

Referring to figs. 1 and 2, A represents a suitable casing containing a horizontal passage therethrough and provided with necks a a', by means of which the casing may be connected between the adjacent ends of pipe sections, or may be applied in other connections according to the use to which the valve is put may require. This casing is provided at one side with a vertical valve seat, B, adapted to receive and be closed by a valve proper, C, thus closing the passage through the casing. The valve proper is provided at its center with oppositely extending flanges c c', to which are connected by horizontal transverse pivots c^2 c^3, the upper and lower ends respectively of sustaining links D D', the opposite ends of said links being pivoted on horizontal transverse axes to the valve casing at opposite sides of the valve, as shown at d d'.

From this description it will be seen that the valve is suspended, as it were, by the two oppositely extending links, this arrangement admitting of the movement of the valve horizontally. It will also be seen that the tendency of the valve to open and close will depend upon the relations of the center of gravity of the valve to the pivoted axes c^2 c^3 of the support, and by suitably proportioning the parts of the valve and adjusting the relations of the axes, and the center of gravity of the valve, the amount of pressure necessary to close or open the valve and the corresponding amount of resistance to its movements may be reduced to a minimum, so that the valve will be truly balanced and will respond quickly to the least variation of pressure on its opposite sides. It will also be noted that the movement of the center of gravity is practically in a straight line, as indicated at E. Its center of gravity moving thus, it will require, of course, less force to move the valve than it would if the center of gravity moved obliquely or in a path other than truly horizontal.

In order that the opening movement of the valve may be limited, I provide a stop, which is represented in fig. 1 as being adjustable, so that the movements of the valve may be regulated or varied. In this figure the upper side of the casing is provided with a depending boss, F, having a vertical

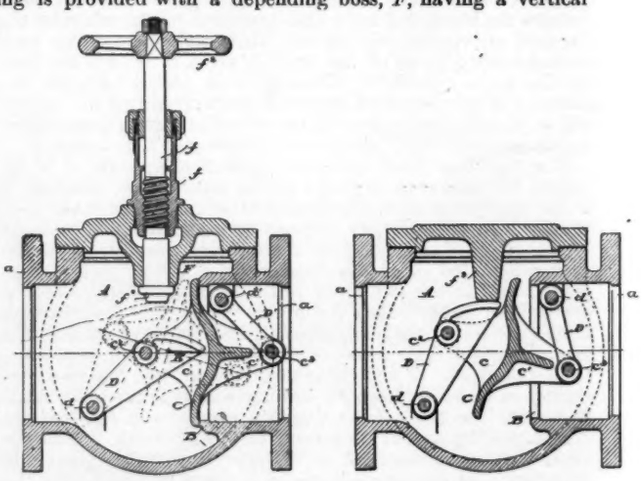


Fig. 1. Fig. 2.

SCHUTTE'S CHECK VALVE.

opening therein, on the upper side of which is fixed a neck, f, into which is threaded a spindle, f', the lower end f^4 of which extends through the boss in the casing to the interior of the same. The upper end of the spindle is provided with a hand-wheel, f^3. The lower end of the spindle is in position to be encountered by the upper edge of the link D when the valve is opened, and by screwing the spindle down through the casing it is obvious that the end of the spindle may be adjusted in different positions to be encountered by the link, and thus vary the movement of the valve. In fig. 2 the stop is in the form of a fixed depending boss, f^5, projecting downward into the casing from its upper side in position to be encountered by the upper edge of the link D, as in the first instance.

The number of the patent is 516,407.